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DESCRIPTIVE STUDY OF THE PETROLEUM  
REFINERY AT MINATITLAN.

by  
Germán García Lozano.

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A  
T H E S I S  
submitted to the faculty of the  
SCHOOL OF MINES AND DETALLURGY OF THE UNIVERSITY OF MISSOURI  
in partial fulfillment of the work required for the  
D E G R E E   O F  
ENRIGEER OF MINES

Rolla, Mo.

1917.

Approved by

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A DESCRIPTIVE STUDY  
OF A  
PETROLEUM REFINERY OF MINATITLAN

In order to reduce as much as possible the cost of transportation of the crude oil to the refinery, the city of Minatitlán of Minatitlán County in the State of Veracruz was chosen as the most proper place for establishing the refinery it being in the center of the only oil fields which at that time possessed the "Eagle Mexican Petroleum Co.

The city of Minatitlán is situated on the left border of the Coatzacoalcos River and about 30 kilometers from the sea. The Refinery is on the same side of the river and on the North-Eastern part of the town, between two marshes and on small hills which are from 20 to 30 mts. high. In the surrounding country there is no dry low land where the Refinery could have been established, so it was necessary to erect it on the small hills causing a considerable initial cost in leveling the land and also a considerable increase in the cost of operation, due to the pumping of water from the river to a tank on a hill 30 mts high. The products produced by the Refinery are transported in tank-barges and tank-steamers to Coatzacoalcos port where the tank-steamers employed for exportation are loaded. A pipe line was constructed with the

object of transporting the oil products to the sea-shipping station, but due to the fact that it was laid in a marsh and very near the surface it was destroyed in five years. Taking this into consideration and also that at present the crude and refined oils, as well as the fuel-oil have to pass by the Coatzacoalcas Harbor, it is my opinion that it would have been more advantageous to have located the refinery near the bar of the Coatzacoalcas River.

The line of communication most useful for the refinery is the Coatzacoalcas River. Its bed has a depth of no less than 16 feet which enables tank-steamers of 8000 and 9000 ton capacity to carry crude oil to the refinery and fuel oil and distillates back to the harbor. All the oil fields of the region send the crude oil to the refinery in tank-barges by the river. Besides, as a rule, all the transportation of machinery, and employees is done through the river by means of the tank-steamers, tugs and gasoline launches which belong to the company as well as in other boats which belong to companies which exploit other natural resources of the region. There is also a railroad branch line 12 kilometers long which connects the refinery and the town with the Isthmus Railroad. This branch line is used considerably for the transportation of refined products to the interior of the country and to some extent also for passenger and freight traffic of the City of Minatitlán.

### HISTORY.

Previous to the exploration in the oil fields of Tuxpan, which brought such good results to the Eagle Mexican Petroleum Co. the Southern region of the State of Veracruz was expected to be of great success. The San Cristobal oil field whose production short after the drilling of the first wells went up to an output of over 30000 barrels a month, much contributed to induce the Eagle Co. to build the refinery. First, in the year of 1906 an experimental plant was constructed on the border of the Coatzacoalcas River at about a kilometer and a half from the town; it consisted of the following apparatus: a crude oil still of 65 barrels capacity with its condenser and inspection box; a steam still of 14 barrel capacity with its corresponding apparatus, two agitators of 60 inch in diameter and 72 inches deep, 8 storage tanks, a 25 HP steam boiler, an air compressor, a crude oil pump, a pump for distillates, a feed water pump for the boiler and an acid pump for the agitators. To control the operation of this experimental plant, a chemical laboratory was established for the purpose of studying the process which later was to be the practice followed in larger scale.

The crude oil first treated was that of the San Cristobal field which is of a different composition to that produced in the Tuxpan region at the "Potrero del Llano" field. The latter is now the principal source of supply of the Eagle Co. The following table show the difference in composition of the two oils mentioned.

POTRERO DEL LLANO CRUDE.

Naphtha.....	from 3 to 6	por cent.		
Illuminants.....	" 12	"18	"	"
Gas-oil .....	" 3	" 5	"	"
Lubricants.....	" 2	" 3	"	"
Paraffin .....	" 0.1	" 0.2	"	"
Fuel-oil .....	" 50	" 70	"	"
Loss.....	" 5	" 10	"	"

SAN CRISTOBAL CRUDE.

Naphtha.....	12.0
Illuminants.....	30.4
Gas-oil.....	20.4
Lubricants.....	19.4
Coke.....	13.5
Loss.....	<u>3.9</u>
	100.0

The San Cristobal oil, which runs much higher in naphtha and illuminants represents well the average composition of the Southern Veracruz oil fields. Hence the refinery was first planed to treat naphthas illuminants and lubricants. The gushers of "Potrero del Llano" which spouted till 1910 made fuel- oil the most important product of the refinery altering considerably the practice established first when the refinery started work in a commercial scale.

The Refinery began operation on may 28, 1908 with the apparatus necessary for a capacity of 2000 barrels a day. It consisted of the following apparatus:

17 stills of 3 mts. in diameter and 9 mts. long with their condensers.

2 stills 2 mts. in diameter and 5 mts. long with their condensers.

5 steam stills 4 mts. in diameter and 17 mts. long with their condensers.

7 lubricant stills 4 mts. in diameter and 10 mts. long with their condensers.

3 condensers of 5 X 5 X 2 mts.

3 agitators of 150, 000 liters capacity each.

8 agitators of 75,000 liters capacity each.

14 sulphuric acid tanks 1 and 1/2 mts. diam and 3 and 1/2 long which supply the agitators.

2 bleachers of 6 and 1/2 X 10 X 5 mts.

11 crude oil stills 4 mts. in diameter by 19 mts. long. with their condensers.

5 re-distillation stills 4 and 1/2 mts. in diameters by 15 mts. long with their condensers.

1 complete sulphuric acid plant.

35 sulphuric acid storage tanks 1 and 3/4 in diameter by 8 mts. long.

1 complete brick factory.

8 steel tanks of 6,750 cubic mts. capacity.

5 steel tanks of 3,000 cubic mts. capacity.

10 steel tanks of 1,500 cubic mts. capacity.

5 steel tanks of 750 cubic mts. capacity.

27 steel tanks 12 mts. diameter by 2 and 1/2 mts. high.

3 gas collectors 1,1/2 X 5 mts.

6 caustic soda tanks 3,1/2 X 2 mts.



With this plant the refinery made various kinds of gasolines, illuminants, lubricants and asphalts and also some fuel-oil, although, as it has been stated the principal object was not to make fuel-oil.

The Eagle Mexican Petroleum Co. had in mind to increase the capacity of the refinery, but they were greatly discouraged due to the difficulty which they found in purifying the products obtained from the Isthmus crudes owing to the great amount of sulphur they contain. Notwithstanding this difficulty the capacity was increased for 1910 in what concerns the production of refined products.

The wells of "Potrero del Llano" which spouted in 1910 gave new growth to the refinery and also determined a change in the process. The change in the refining practice was not only due to the enormous capacity of the oil well in Potrero del Llano but also to the fact that this oil contains less amounts of naphthas and illuminants and more paraffins; besides by this time the production of the San Cristobal field had diminished considerably; hence, since this time the refinery has devoted its attention to the treatment of the Potrero del Llano crude oil. It is due to this change in the source of supply, that the principal object of the refinery is now to make fuel-oil, making use at the same time of the lighter constituents to make gasolines and illuminants, and of the paraffin oil to make paraffin wax and lubricants. The only modifications which suffered the refinery to fit new conditions

was the construction of a paraffin-wax plant and an asphalt plant. At the present time the refinery has a capacity of 12,000 barrels a day.

#### GENERAL DESCRIPTION.

The Refinery is composed of the following departments: Continuous stills for crude oil. The first treatment to the oil that comes from "Potrero del Llano" is given in this plant. It is composed of 15 stills with their condensers and inspection boxes; preheaters for crude oil and superheater for steam: 8 stills for treating the crude oil that comes from the South of Veracruz as well as from Furbero. This are exactly alike to the ones used for Potrero del Llano crude and are also provided with their condensers and inspection boxes.

Gasoline Plant. This plant refines crude naphtha which results from the first distillation of the crude oil and produces gasoline and kerosene. It is composed of 9 steam stills with their respective condensers deflegmators and inspection boxes.

Asphalt Plant. It produces asphalt and tarry paraffin oils as distillate. It is composed of 10 continuous stills which obtain the tar for treatment from the residuum of the crude oil distillation, they are also provided with their condensers deflegmators and inspection boxes.

Paraffin Wax Plant. This plant treats the paraffin oils which result from the last distillation of the crude oils as also the tarry paraffin oil from the asphalt plant, and produces paraffin wax and heavy oils which pass to the lubricant plant. The paraffin wax plant is composed of a



GENERAL VIEW OF THE REFINERY



CRUDE OIL DISTILLATION PLANT.

refrigerating machine, coolers for the paraffin oils, - filter-presses, "sweating" chambers agitators for bleaching and purifying, molds for freezing the paraffin wax - into blocks. It has besides an small ice plant.

Lubricant Plant. It is composed of 7 stills with their respective Condensers deflegmators and inspection boxes.

The fuel-oil is made in the tar storage tanks. The tar sults as residuum from the distillation of the crude oil; in this tanks it is mixed with the proper proportion of gas oil to make the required fuel-oil.

As complementary plants there are: the agitators which purify the distillates (gasolines, illuminants, lubricants and sometimes gas-oil) in their different stages of treatment; redistillation stills whose object is to - obtain a better fractional separation of the crude distillates, giving to each charge a treatment as specified by the laboratory, and the chemical laboratory where all the research work is initiated and where all the samples obtained of the different oils in their different stages of treatment, as also the final products, are analyzed. - This department gives daily the instructions which are - to govern the process to be followed by the refinery.

Supplementary Plants. Plants which do not aid directly in the process of refining but which indirectly - are necessary to the refinery are:

Electric Power Plant. It is composed of two parts, an old plant of Diesel internal combustion engines direct

ly connected to electric generators which is not in use, - and a plant of steam turbines directly connected to electric generators which is the one now in use; it is provided with Babcock boilers. This plant furnishes the refinery with all the power and light needed.

Water Pumps. This plant consumes most of the power - produced by the electric power plant; it is composed of - electric motors directly connected to centrifugal pumps - which feed a storage tank of 45,000 barrels capacity, from where the water is distributed to the different departments of the refinery.

Sulphuric Acid Plant. This is a complete modern type of acid factory using a combined process of lead chambers and Gay-Lussac and Glover towers, but due to its small - capacity only produces half the acid required by the refinery.

A Can and Barrel Factory. which is divided in two - parts; one makes tin-cans for distillates and lubricants and the other, barrels for packing asphalt.

Pumping Stations. There are 9 pumping stations for distillate, crude and fuel-oils; 2 for distillates, 1 for tar, 2 for the agitators, 1 for asphalt, 1 for the shipping wharf, 1 for crude oil and 2 for lubricants.

Steam Boiler Plants. There are two; one furnishes the steam necessary for the crude oil stills, as well as for the asphalt and re-distillation stills, and the other which furnishes steam to the steam stills and lubricants

stillls. Both plants also furnish steam for general uses.

Machine Shop which does all the repair work for the refinery.

Plumbers Shop which does all the work related with the pipe-lines.

Storage Tanks. All are steel tanks, 38 are large - tanks whose capacity varies from 10,000 barrels to 55,000 barrels and 33 are smaller tanks of 1,000 barrels capacity. The bleachers and some other small tanks are used for storing lubricants and some refined distillates before shipping.

#### OFFICES AND DWELLING-HOUSES.

The principal offices are wooden structures situated on the border of the river. One is for the General Manager its departmens and the tecnic Superintendent and the engineering department. The other building is the marine department which has in charge the ships which carry oil to the gulf ports. The manegers of the other principal departments of the refinery have their office near the plant -- they have in charge.

For the chemists, engineers and office men the Eagle Co. has contructed 422 dwelling-houses; of these 9 are divided into departments and the rest, which are nearer the refinery are separate small houses. Inside the grounds of tee refinery live the marine superintendent, the power house superintendent and the acid plant foreman. On the border of the marsh west of the refinery is a samall Chinese Colony.

#### OBJECT OF THE REFINERY.

Notwithstanding the simpleness of the process used

in the refining practice, with a small variety of apparatus employed, the refinery produces two kinds of illuminants, two kind of gasolines, 25 kinds of lubricants, 3 kinds of paraffins, gas oil and fuel-oil as required by any specifications and about six kinds of asphalts.

In this respect a refinery can not be considered as an ore-dressing mill, where to a deffenite kind of mineral is applied an especial treatment previously determined by experimentation, getting and arranging the machinery necessary to obtain a meximun commercial efficiency; once established, the ore-dressing mill does not require any more attention than that necessary to make its operation uniform, and sometimes suffers a grate change in its arrangement adn apparatus when there is a small variation in the composition of the ore. In a refinery, what is done in the laboratory is carried to a large scale and almost with the same apparatus only larger; hence with stills, deflegmators, condensers and agitators all the products derived from the crude oil (except paraffin wax) can be manufactured and a considerable variation in the composition of the crude oil does not alter the arrangement nor necessitates a variation in the kind of apparatus, On the other hand it becomes necessary to have a chamical laboratory in charge of a qualified chemist who considering its general characteristics must establish the refining system suitable for the crude oil to be treated, and who must direct all the operations of the refinery, changing them as it be needed in order to obtain the different products demanded. The key of the refinery does no lie in the

kind of apparatus used, but in the especial process which has been studied by experiment for making the different products manufactured by a refinery. These formulas are kept secret by the refinery and are only known by the -  
tecnic superintendent and his assistants.

Therefore the chemical laboratory is one of the -  
most important departments of the refinery. It is provided with all the apparatus necessary to do all the -  
analyses related to the physical and chemical properties of petroleum and other organic oils which are imported -  
to mix with the distillates obtained from the Mexican -  
crude oil. The organic oils usually bought for this purpose are lard oil, cotton seed oil, acidless tallow oil rosin oil and a few imported lubricants.

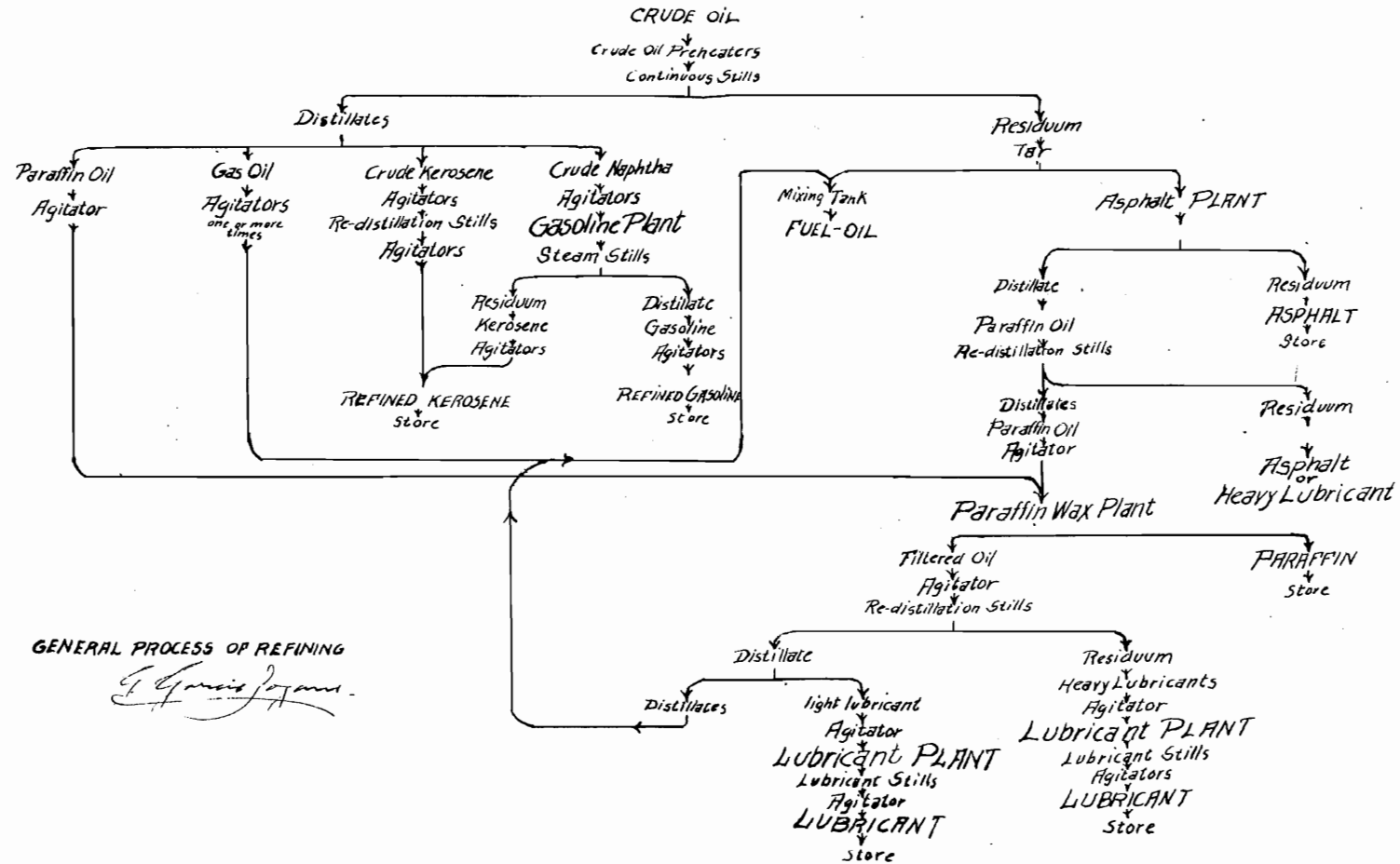
#### GENERAL PROCESS OF REFINING.

First I will describe the treatment applied to the "Potrero del Llano" crude which is the most important -  
treated by the Refinery; the rest of the crude oils which the Eagle Co. refines with little variations, follow the same process but are treated separately during the first steps due to their difference in composition, especially the Tecuanapa crude which is used with preference to make lubricants (see flow-sheet plate No. 1.)

The crude oil is first treated in continuous stills of the Nobel Bros. system; from these tar is derived as residuum and as distillates, crude naphtha, crude kerosene, gas oils and paraffin oils. The gas oil and the tar are mixed in the mixing tanks in certain proportion to



# PLATE N°1



GENERAL PROCESS OF REFINING

*L. Francis Johnson*

make the fuel-oil as specified by the consumer; the --  
paraffin oils which contain the oil from which lubricants  
are made as well as small amounts of gas-oil, is first -  
purified in the agitators, re-distilled, purified again -  
in the agitators in order to remove all the tar which would  
be troublesome in the paraffin wax plant. The crude naphtha  
is first treated in the agitators and then goes to the --  
steam still where it is separated from the kerosene which  
was carried mechanically in the first distillation of the  
crude oil. The steam stills produce gasoline as a distillate  
and illuminants as a residuum, these being the only  
two products obtained from the steam stills. Only when the  
crude naphtha contains ethers, benzine is produced as the  
first distillation of the crude naphtha. Finally the ga-  
soline and kerosene are given a last treatment with acid  
and alcaly in the agitators and are then in marketable -  
condition.

The crude illuminents (kerosenes) are treated twice  
in the agitators with acid and alcaly, and when it is --  
desired to obtain a better class of illuminsnt it is -  
re-distilled before giving it the second treatment in -  
order to remove the small amounts of gasoline which it  
may contain as well as some heavier oils which it may have  
carried mechanically in the distillation of the crude oil.

When the gas oil in going to be used to mix whith  
tar ("flux") to make fuel-oil, it is generally only treated  
once in the agitators; but when it is to be sold for inter  
nal combustion engines or for the manufacture of illumi-

nating gas, then it is treated in the agitators with acid and alcaiy as many as three times in order to remove the largest amout of sulphur possible.

The paraffin oil as has already been stated, is first purified before going to the paraffin wax plant where the impurities would render it difficult to make good paraffin. In the paraffin wax plant the paraffin oil is first chilled to separate the paraffin from the oil which is filtered in the filter-presses. Taking advantage of the differece in the melting points of the different paraffins, a separation of them is obtained in the "sweating" chambers, producing by this device three kinds of paraffins which are treated separatly in two especial agitators with acid and Fuller's earth respectively to purify them as a final step.

The oil which results as filtrate from the filter-presses in the paraffin wax plant are first purified in the agitators and then re-distilled in the lubricant plant which produce gas-oil and lubricants as a distillate and as a residuum asphalt or heavy lubricants.

From the "sweating" chambers an oil with a large amount of paraffin is obtained besides the paraffin-wax, This oil is distilled, producing as a distillate, paraffin oil which is treated again in the paraffin wax plant, and as a residuum white asphalt.

The lubricating oil which result from the re-distillation stills are first purified in the agitators and then pass to the lubricant stills where they are given an especial

treatment to produce the lubricant required. As a rule, the first product of distillation in these stills is - gas-oil foll-owing next light lubricating oils and remaining as a residuum, heavy lubricants. This is not always the case, for when an oil is tretaed that is a residuum - from the re-distillation stills, due to the fact that there is a heavy oil to start with from which the lighter parts have already been distilled. The products obtained from - the lubricant stills in this case is heavy lubricants as a distillate and asphalt as a residuum. The stills of this plant work intermittingly. All lubricants are given a final washing whith acid and alcaly in the agitators.

There are in the refinery 8 bleacher tanks which - originally were for the purpose of sunning the oils that had received the last treatment in the agitators, but later the refinery has considered them useless for this object and are now employed only as storage tanks.

To make some of the especial marks of lubricants, organic oils and imported lubricants are mixed to the lubricants which result from the distillation of the Mexican - oils.

Part of the tar that results as a residuum of the - continuous crude stills is employed to furnish prime material for the asphalt plant which produces paraffin oil as a distillate and asphalt of the kind desired as a residuum. The paraffin oil which results from these stills carries mechanically large amounts of asphalt which would

clog the filter-presses. Therefore it becomes necessary to re-distill it first to remove the asphalt. The paraffin oil which distills off is put together with the other paraffin oil derived from the crude stills.

Of the four products which result from the distillation of the crude oil, the largest in amount is tar which mixed with gas oil makes the fuel-oil this being the principal product of the refinery.

The principal object of "topping-plants" is also to make fuel-oil; but differs from this refinery in that the only products which they produce are crude naphtha and illuminants which they export to refine in the exterior, and do not separate the paraffin oils as it is done in this refinery, to make paraffin wax and lubricants. Not only do topping plants produce fuel-oil of lower grade, but also waste the paraffin wax and lubricants which have a considerable value; besides this refinery does not produce any product in the crude state but sends them all to the market as finished products.

#### TREATMENT OF THE FURBERO AND ISTHMUS CRUDES.

The crude oils from Furbero, Ixhuatlan and San Cristobal are, as a rule, distilled together. Before, the San Cristobal crude was treated separately, but its out-put has diminished considerably and now these three oil fields mentioned produce little oil in comparison with "Potrero del Llano". Therefore they are stored together sometimes the water is only removed by warming them and used this way as

fuel-oil in the refinery. This is done due to the fact that the amount of sulphur which they contain is relatively - - large and although the amounts of naphthas and illuminants is large, the sulphur contents makes it difficult to obtain good products; nevertheless they are often distilled to - separate the naphthas and illuminants which receive the - same treatment as the distillates produces from the "Potrero del Llano" crude.

On the other hand the best crude oil of the Eagle - Co. is that produced in Tecuanapa. This oil field of the Southern region of the State of Veracruz produces only - about 3,000 barrels a month of a high grade oil which can be used almost in its crude state as lubricant. The following is an analysis of the Tecuanapa oil.

Sp.Gr.at 60°Fahr.....	0.852
Flash Point.....	50°Fahr.
Ignition point.....	95°Fahr.
Viscosity at 60°Fahr.....	50 seconds (Redwood)
Calories.....	10,616
Sulphides.....	0.99
Odor.....	Hydrogen Sulphide.

Distillation.

Naphtha.....	8 per cent
Illuminating oils.....	39 "
Gas-oil.....	10 "
Lubricating oil.....	34 "
Asphalt.....	4 "
Loss.....	5 "

The good quality of this oil consists in its large percentage of gasolines, illuminants and lubricating oils and in the small amounts of asphalt and sulphur. Removing from this oil the kerosene and gasoline contents which - makes its flash point so low and therefore dangerous for using in its crude state, it can be used directly as a -

lubricant, since the 10% gas-oil and the 4% asphalt do not impair its qualities as lubricating oil. Nevertheless the Tecuanapa oil receives a better treatment in order to obtain from it the best lubricant made by the refinery. This oil is distilled first to produce as a residuum asphalt, and crude naphtha and illuminants, - gas-oil and lubricants as a distillate. The lubricating oil fraction goes first to the paraffin wax plant, it is then purified in the agitators and goes lastly to the - lubricating stills resulting gas oil and one or more -- kinds of light lubricants as distillate and heavy lubricants as a residuum.

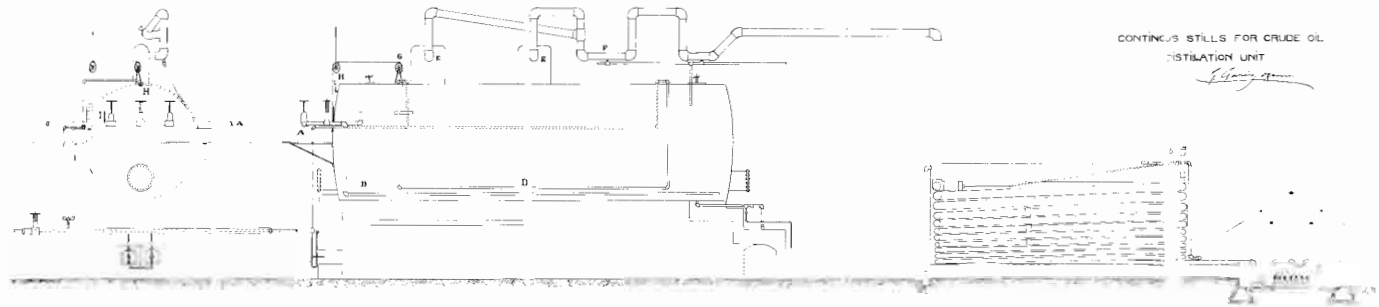
#### CRUDE OIL DISTILLATION PLANT.

This is the principal department of the refinery and has been given the name of "Potrero del Llano Crude Oil Plant" because it refines totally the oil that comes from that place.

This plant can be considered as the foundation of the refining process; from here is derived the material which supplies the asphalt, paraffin, gasoline, lubricants and kerosene plants as well as the material necessary for making the fuel-oil.

The crude oil distillation plant is composed of 15 stills of 1,000 barrels capacity each with their - corresponding condensers and inspection boxes.

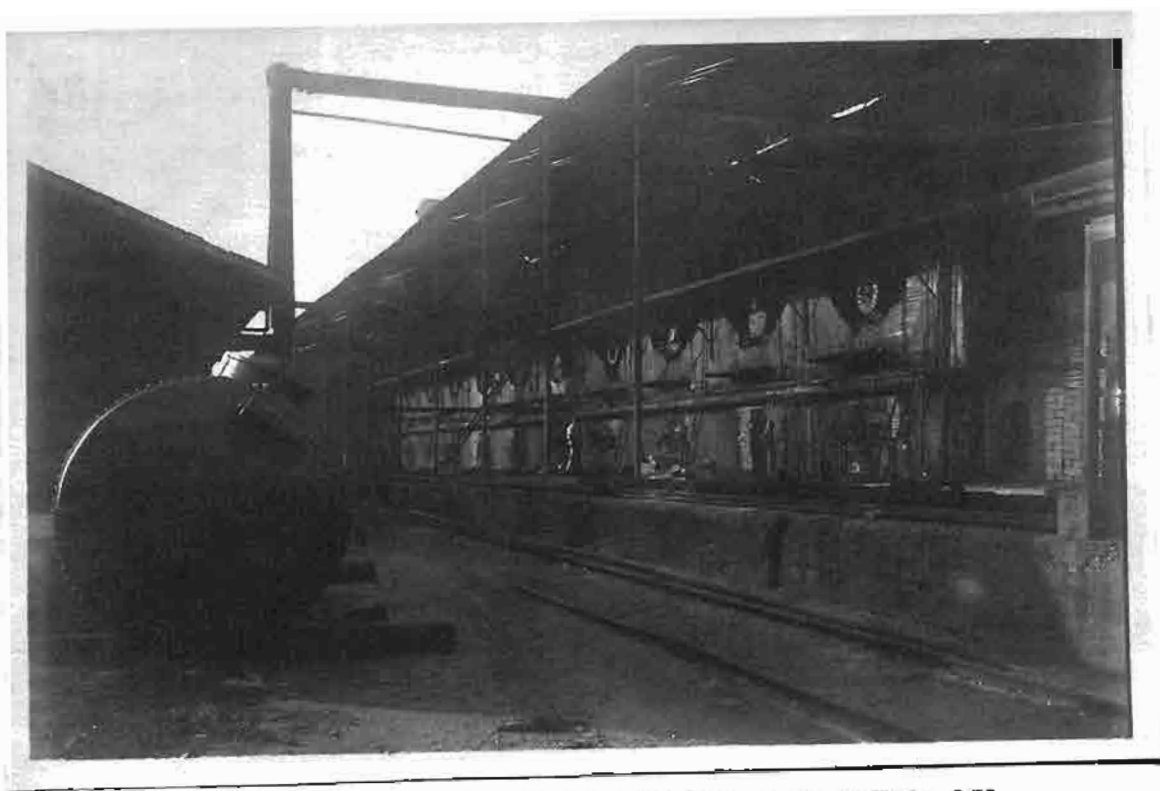
The stills used are of the Nobel Bros system of continuous distillation and are similar to a non-tubular "Cornish" boiler (see plate No. 2) They are 15 mts. long



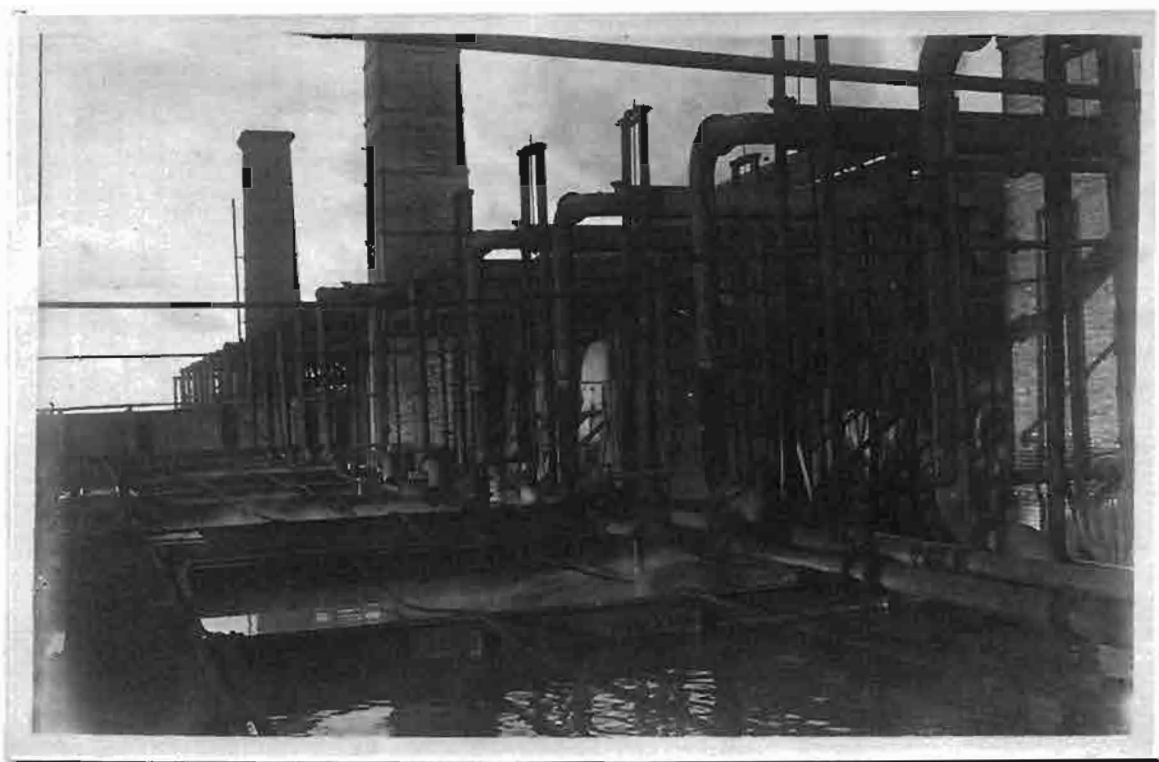


and 4 mts. in diameter. The stills No. 9 to No. 15 are a little shorter but of equal diameter. They are made of sheet iron and are supported by brick walls which are reenforced with steel rods to protect them against big changes of temperature. The lower empty space forms the furnace having only three or four meters of brick arch in the front part under the still to prevent the flames from playing too fiercely on the sheet iron. Tar which results from the same continuous stills is used as fuel for the distillation of the crude oil. Each furnace has two burners which use steam to atomise the oil. Two chimneys do the draft for all the crude stills and also for the asphalt stills. The continuous stills receive the oil thru a six inch main feed tube (A) having for each still three valves, one in the main itself and one in each of the two tubes which connect the main to the stills. Closing the main valve and opening the side valves, the oil is forced to flow thru the still, and opening the main valve and closing the side ones, the still is separated from the series, this being done when it is desired to repair a still or to use it as an intermittent still.

As the oil enters the still it descends thru an elbow to the bottom and is distributed lengthwise in the still by means of a perforated six inch tube which extends all the length of the still. The stills are filled up to 2 and 1/2, or 3 meters high, when the oil flows out thru an elbow turned upwards (C) which is connected in the outside with the main. Revolving this elbow the height



FRONT VIEW OF CONTINUOUS STILLS FOR CRUDE OIL



CONDENSERS OF THE CONTINUOUS STILLS

of the oil in the still can be varied.

In the bottom of the still there is a sort of a - grate (D) formed by four 2 inch perforated tubes which extend all the length of the still: two vertical tubes connect the extremities of this grate with the steam main in the outside. Superheated steam is supplied to the oil thru the perforations of the grate tubes at a pressure of 80 pounds per sq. inch. The use of steam was first introduced into the refining of petroleum by Von Matscheko in Austria and by A. Merrill of the Dower Kerosene Oil - Co. in the United States. It has the object of carrying the distillates out of the still as soon as they - are formed, preventing in this way their being condensed in the roof of the still "cracking" as they fall on the hot oil: besides, steam aids to agitate the oil: it is a factor of importance in regulating the formation of distillates, the other factor is the heat, being better to keep constant the steam and vary the heat. The steam must be supplied at a high temperature and at a low - - pressure and as the steam from 12 to 20 pounds pressure, which is the maximum allowed inside the stills, has a - temperature of about 259 Fahr. this steam would tend to cool the oil that is being distilled necessitating more fuel and consequently a higher cost in the distillation process. To avoid this loss, the refinery has established superheaters which consist in a series of tubes connected with "U" tubes so as to make the steam travel a long distance in a small furnace. These heaters are made of six -

horizontal and eight vertical rows of 4,1/2 inch tubes placed in a rectangular brick chamber 3,1/2 by 5 meters long, which constitutes the furnace heated by two oil - burners. Each superheater has a steam pressure gage and a galvanometric pyrometer to register the pressure and temperature of the steam leaving the superheaters. The temperature of the steam is usually of 400 to 500 degrees Fahr. and its pressure of 60 pounds. This is not the best system for heating steam for refining purposes. In the first place, it wastes much heat due to the poor construction of the brick furnace which permits large amount of heat to radiate, much heat is wasted in the chimney of the superheater and lastly the steam is cooled while - being conducted from the superheater to the stills, no - matter how well insulated be the transmittion pipe; and second it is bad practice to supply steam at equal temperature to a series of continuous stills, especially if each stills is distilling oils at a different temperature from the rest, in this case the steam at a given temperature is eather too high for the stills where the - lighter oils are being distilled, or is too low for the stills where the heavier oils are being distilled. In - the first case heavier oils are carried by the hot steam togeather with the naphthas and in the second case more fuel is necessary for the distillation of the paraffin oils.

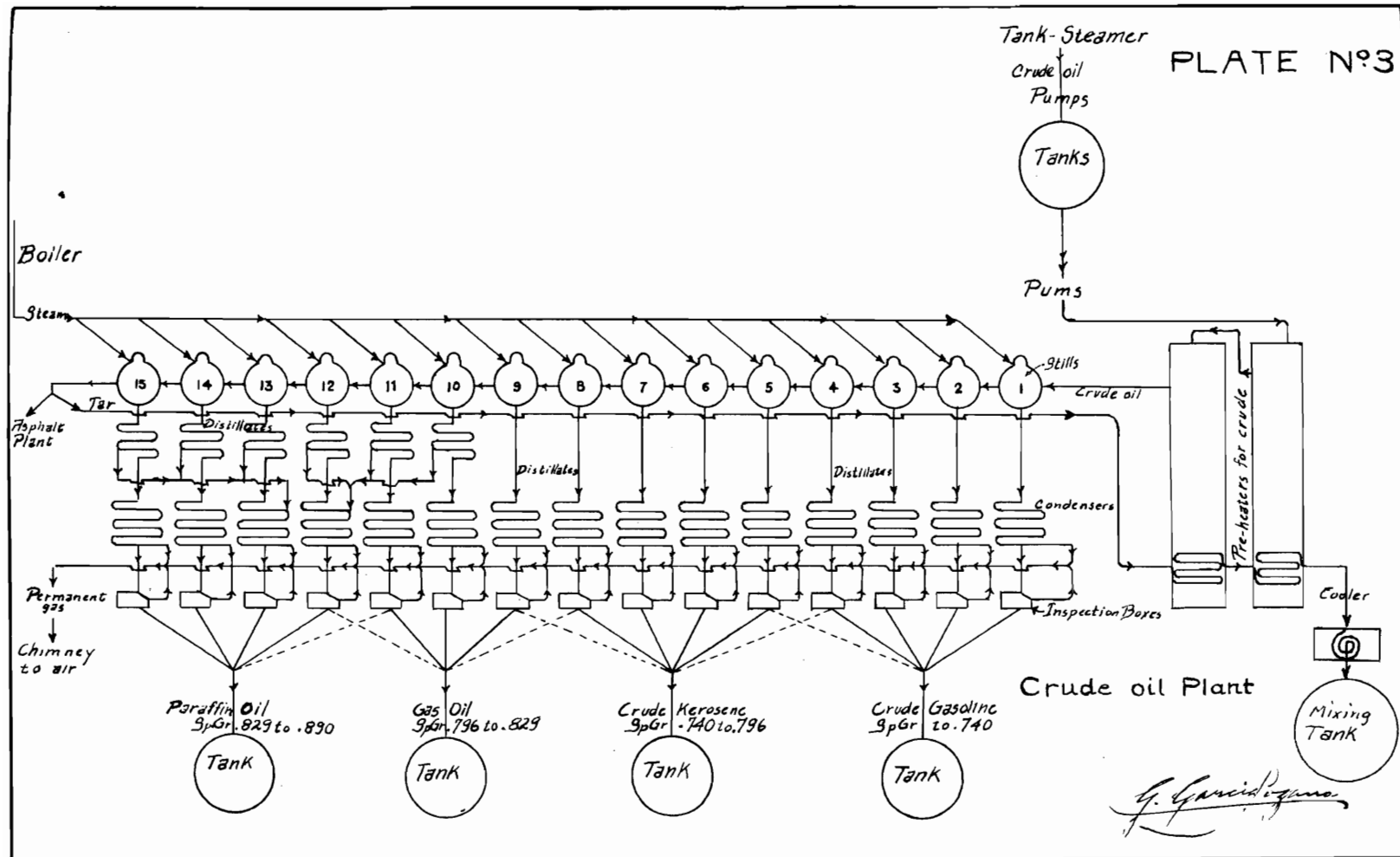
Each still has two tubes (E) connected to its two domes which carry the gases produced in the still direct

ly to the condensers. Before, three of the stills were provided with vertical deflegmators, the rest were connected to a pipe with two bends (F) connected in the lower part with a 2 inch tube which collected all the oils that had been carried mechanically by the vapors, having therefore the same object of a deflegmator. - - Stills No. 10,11,12,13,14 and 15 send the oil that collects in the deflegmator tube, to a small condensers. Large quantities of oil result from the deflegmators - of this stills due to the high temperature at which the oil is distilled in them. To one of the domes is connected a vertical 2 inch tube which serves as an air inlet when the still is emptied. The stills are provided with a man hole in each extremity.

To know the quantity of oil that is in each still, there is a float inside connected with a wire rope to an indicator (G) in the outside. Besides each still has a pressure gage on the top, to register the pressure of the gases and a Fahrenheit thermometer in the oil main (I) between each pair of stills which show the temperature at which the oil has been heated in the preceding still.

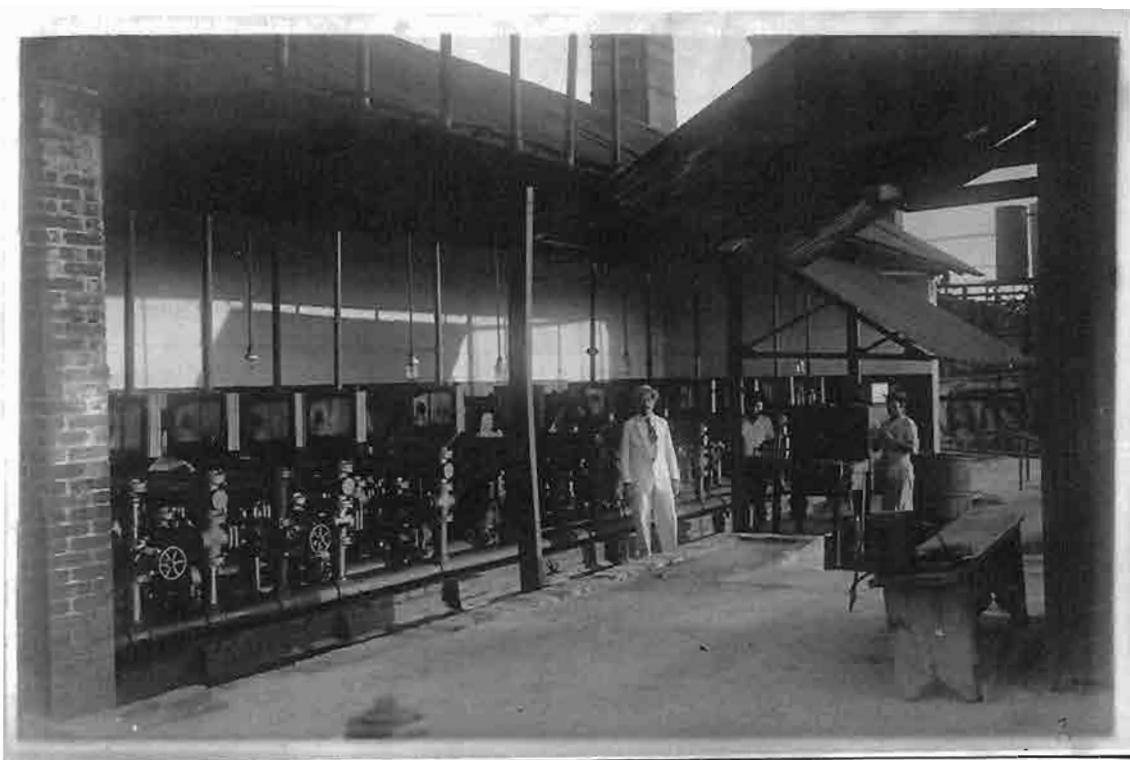
The crude oil enters first the still No. 1 and - after passing thru all the stills leaves still No. 15, all the naphthas, kerosenes, gas oil and paraffin oils having been distilled off from the crude by this time.

A small part of the tar which leaves the oil main in still No. 15 goes to the asphalt plant; the rest after



heating the crude oil in the preheaters goes to coolers from where it is pumped to the storage tanks or to the mixing tanks where the fuel-oil is made.

The distillates pass directly from the stills to the condensers (see plate 2). These are of the coil system where water is the cooling medium. They are formed of large rectangular tanks with a tube coiled around the wall of the tank. The first round of the coil is of 8 inch tube, two rounds of 6 inch tube and 9 rounds of 4 inch tube, making a total length for the coil of 190 meters. The number of rounds for tubes of different diameter varies sometimes, but the total length is always the same. The water used for the condensers is returned to the river. The coil has an escape for the non-condensable gases like hydrogen sulphide and gaseous hydrocarbons. The condensers are provided also with a safety pressure valve and another for vacuum in the first coil; the pressure valve has the object of avoiding damage caused in the condenser or the inspection boxes by a sudden pressure formed in the stills, and the vacuum valve is to avoid a sudden rush of cold liquids to the still when this is cooled suddenly, or when it is emptied a flow of cold distillates and water into the hot still would produce an explosion. In the condensers No. 12 and 13 there is a small coil similar to the ones used in the asphalt plant which are for the purpose of cooling the oils collected by the tube-deflegmators. The oils corresponding to the deflegmators of stills No. 10, 11, and 12 are collected in the small coil of condenser



INSPECTION BOXES



CRUDE OIL PREHEATERS



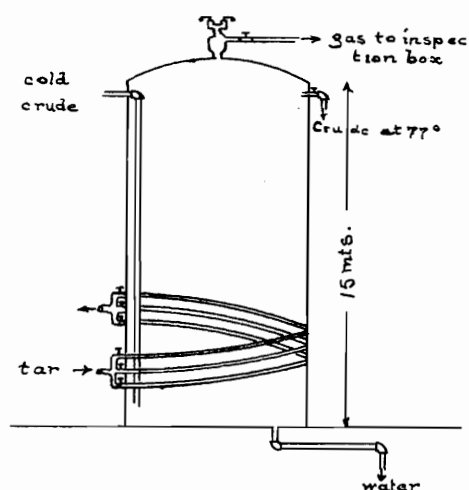
No. 12 and that of stills No. 13, 14 and 15 in the small coil of condenser No. 13. The small and large coil of each condenser are connected, so that the oil collected in both goes together to the inspection boxes.

The water is furnished to the condensers at atmospheric temperature and leaves it at 130° Fahr: the condensed distillates are cooled to 90°, 100° or 110° Fahr. when the distillates are heavy. The water leaves the condenser at a higher temperature than the oil, because the water comes in contact last with the hottest coils,

The distillates together with the condensed steam go to the inspection boxes. The permanent gases escape from the top of the boxes thru a two inch tube connected to a pipe line which carries all the permanent gases to the chimney. The inspection box house has 113 boxes; 12 correspond to Stills No. 4 to 15 and one corresponds to the gases from the crude oil preheaters which in other time were condensed. The inspection boxes of stills No. 1, 2, and 3 are in house No. 2. The 13 boxes corresponding to the stills first mentioned are provided with seven connections in order to be able to distribute the oil collected in each inspection box thru seven pipe lines, and the other three are arranged to distribute the oil thru nine pipelines. In the inspection house No. 2 are the inspection boxes corresponding to the re-distillation stills and to the stills which treat other crude oils.

The crude oil pumped from the tank steamers to the

storage tanks is heated first in preheaters 15 Mts. high and 7 Mts. in diameter (see Fot.No.6) and of 3,000 barrels capacity. The crude oil enters the tank thru the top and descends thru a tube to a meter from the bottom. The outlet is on the upper part of the tank and in front of the entrance tube. The crude oil is heated by means -



of a coil of three rows which branch out from the main that carries the tar that results as a residuum from still No. 15 - and which has a temperature of about 600° Fhar.; the three tubes go once around the lower inside part of the tank and are connected again in the outside of the tank to the tar pipe line. This coil can only occupy the lower part of the preheater

because the head that causes the flow of the tar is the height of the oil in the stills and hence the coil can be no higher than the level of the oil in the stills. At the bottom there is an outlet for the purpose of removing the water that collects on the bottom. On the top dome of the heaters there is a pressure and a vacuum valve and an outlet for gases which used to be collected to make ethers. The crude oil enters the preheaters at atmospheric temperature and leave it at a temperature of from 70° to 80° C. If the two preheater are used they are - -

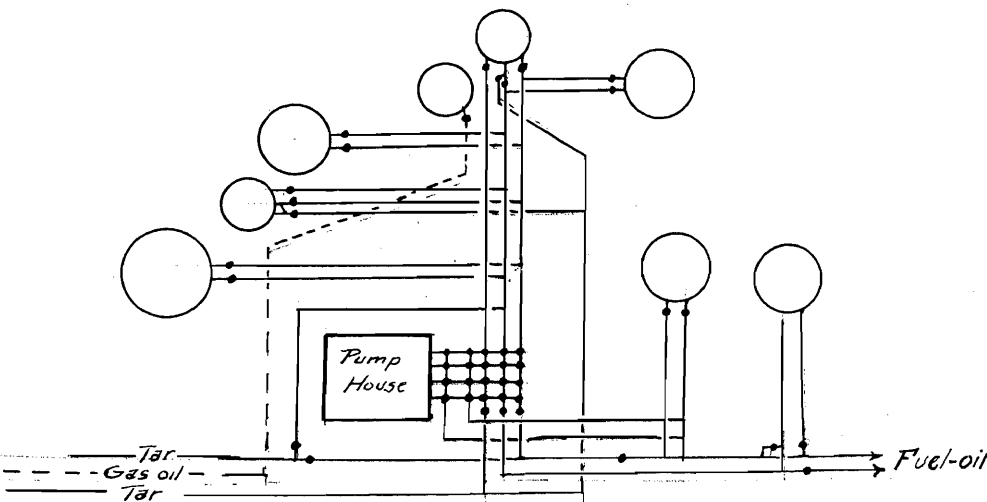
connected in series, the crude oil moving in opposite - direction to the hot tar; that is, the hot tar flows first thru the coil of heater No. 1 and then thru that of No. 2, while the crude oil enters first heater No. 2 and then goes to heater No. 1 where the tar in the coil is hottest. As a rule only one preheater is used, although more water is separated from the oil when the two are used together. From the preheaters the crude goes directly to still No. 1 of the series of continuous stills.

The distillates from the first three stills are distilled at a temperature of from  $77^{\circ}\text{C}$ . to  $110^{\circ}$  and  $150^{\circ}\text{C}$ . and produce crude naphtha which goes to inspection box - No. 1, 2, 3 and 4 having a Sp.Gr. of from 0.689 to 0.740. The distillates produced in stills 5 to 8 at a temperature of from  $150^{\circ}\text{C}$ . to  $300^{\circ}\text{C}$ . are crude kerosenes with a Sp. Gr. up to 0.796. The oils distilled from stills No. 9 to 11 at a temperature from  $300^{\circ}$  to  $350^{\circ}\text{C}$ . are gas-oil with an Sp. Gr. to 0.829 and the oils distilled from stills 12 to 15 at a temperature from  $350^{\circ}\text{C}$ . to  $400^{\circ}$  are paraffin oils with an Sp.Gr. of 0.890. Each distillate is stored in its corresponding tank.

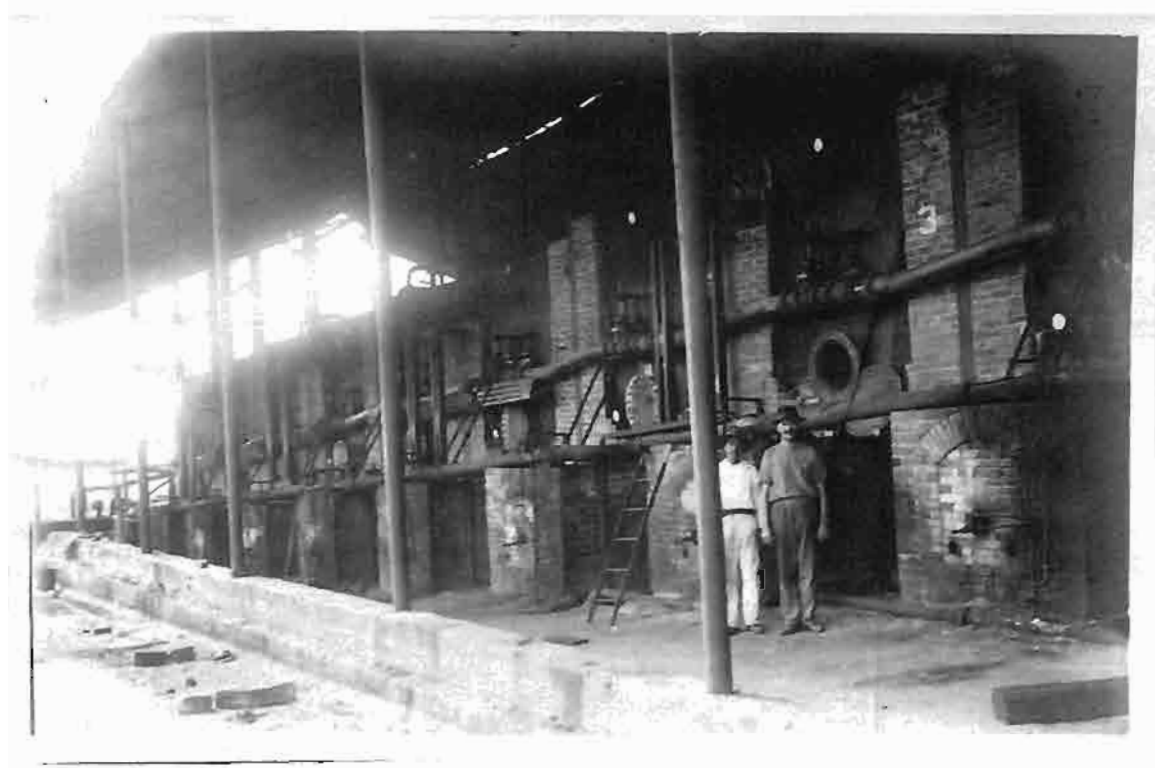
This practice is changed depending on circumstances; for not only is the density of the distillates subject to variations, but also the separation of one or more stills from the series of continuous makes a great change in the distillates produced by the following - stills. The superintendent of the refinery knows before hand by experiment, what products are to be obtained from a given charge and accordingly each foreman of the in-

spection houses receives daily a table in which is specified what are the Sp. Gr. limits of the fractions to be separated and how are they to be distributed; the regimen of a still is therefore not fixed, but varies with the composition of the charge and with the change of the Sp. Gr. of the fraction distilled. Due to the manifold valve and pumping arrangement of the refinery, any distillate can be pumped direct to any of the storage tanks although it is always preferable to assign a tank for each kind of distillate and avoid the necessary washing when a different product is to be stored.

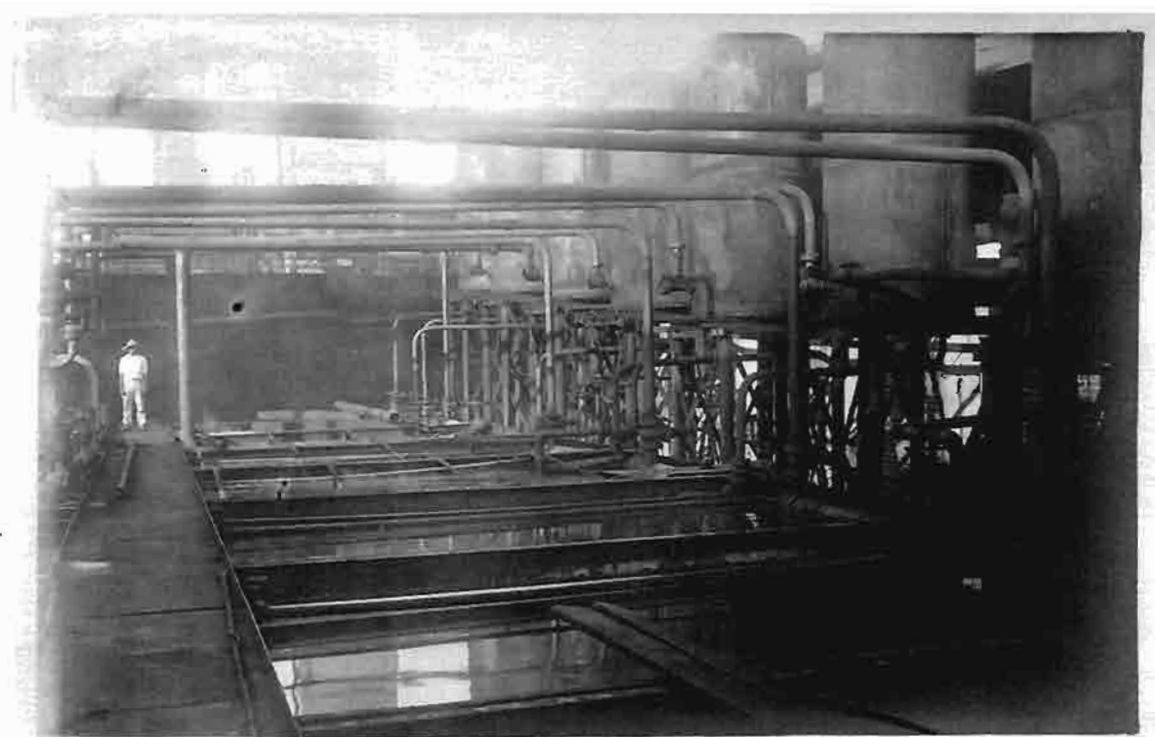
The tar, which is the residuum obtained from the continuous stills is stored in the mixing tanks where the fuel oil is made by mixing to the tar the amount of gas-oil necessary to fill the specification required by the purchaser. Pump house No. 2 does all the pumping necessary for making



the fuel-oil and by the manifold arrangement of valves gas oil and tar can be pumped to any of the tanks as shown in the sketch.



ASPHALT STILLS



DEFLEGMATORS AND CONDENSERS OF ASPHALT PLANT

The distillates are pumped from the tanks where - they are stored to the plant which is to refine them.

The capacity of the crude oil continuous stills is of 15,000 barrels, although as a rule, due to the fact - that not all the stills are always in operation, only treats about 10,000 barrels daily. The crude oil from - "Potrero del Llano" contains from 1/2 to 2,1/2 per cent water and produces about 60% tar, from 3 to 6 percent - crude naphtha, 12 to 18 per cent crude kerosene, 3 to 5 per cent gas oil, and 2 to 3 per cent paraffin oils. This plant consumes in fuel 2,1/2 per cent of the crude oil treated and 750,000 pounds of steam a day. The work - shift is composed of a still foreman and an assistant, a fireman and a man in charge of the inspection house.

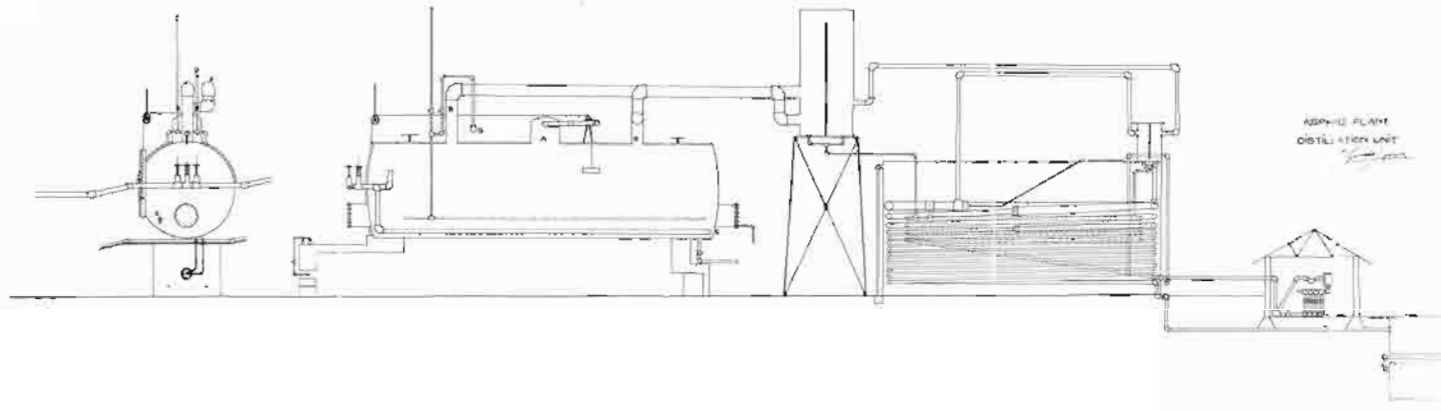
#### ASPHALT PLANT.

The asphalt stills are placed following the 15 - crude continuous stills. The tar pipe line as it leaves still No. 15 is divided into two branches: one carries most of the tar to the storage tanks and the other branch furnishes <sup>the</sup> asphalt plant with tar. A brick wall divides this plant from the crude oil distillation plant.

It has a capacity of 1,500 barrels of tar but it usually treats 1,200 barrels of tar daily; the capacity of the plant varies considerably with the kind of asphalt that is made, being able to treat more tar in making softer asphalt than when hard asphalt is made. The plant is composed of a series of ten continuous stills of the Nobel - Bros system, but of 260 barrels capacity each. The stills

are placed one on the side of the other and each 9 inches lower descending from still No. 1 to still No. 10. Each set is composed besides the still, of its condenser two deflegmators and an inspection box. Stills No. 1, 3 and 10 have only one deflegmator. As a rule one still is disconnected from the series and reserved in case another gets out of order. The plant has besides two boxes with coils to cool the asphalt as it leaves the last still. One is 14.50 X 1.90 X 1.45 Mts. and the other is 12.40 X 1.30 X 1.20 Mts. The pipe line which carries the asphalt to the barrel factory and to the asphalt store on the border of the river (this burned down lately) has in the interior a 1,1/2 inch steam pipe which is connected at regular intervals with the steam main; this interior steam pipe has the object of preventing the asphalt from solidifying in the pipe line. When the asphalt pipe line is not in use, it is blown with compressed air to remove all the asphalt that may remain in it.

The stills of this plant (see plate 4) only have one dome (A) which before was used for the outlet of the gases, but now is connected to a pipe line from which the stills can be filled separately and worked intermittingly. The distillates leave the still thru two 12 inch tubes (B) which are in the upper part of the still, one towards the front and the other in the back part. These go directly to the deflegmators. The stills have in the bottom and in the back extremity an outlet for the residuum thru a 6 inch tube (C); this tube being only used when the still in being worked intermittingly, or also when it is desired



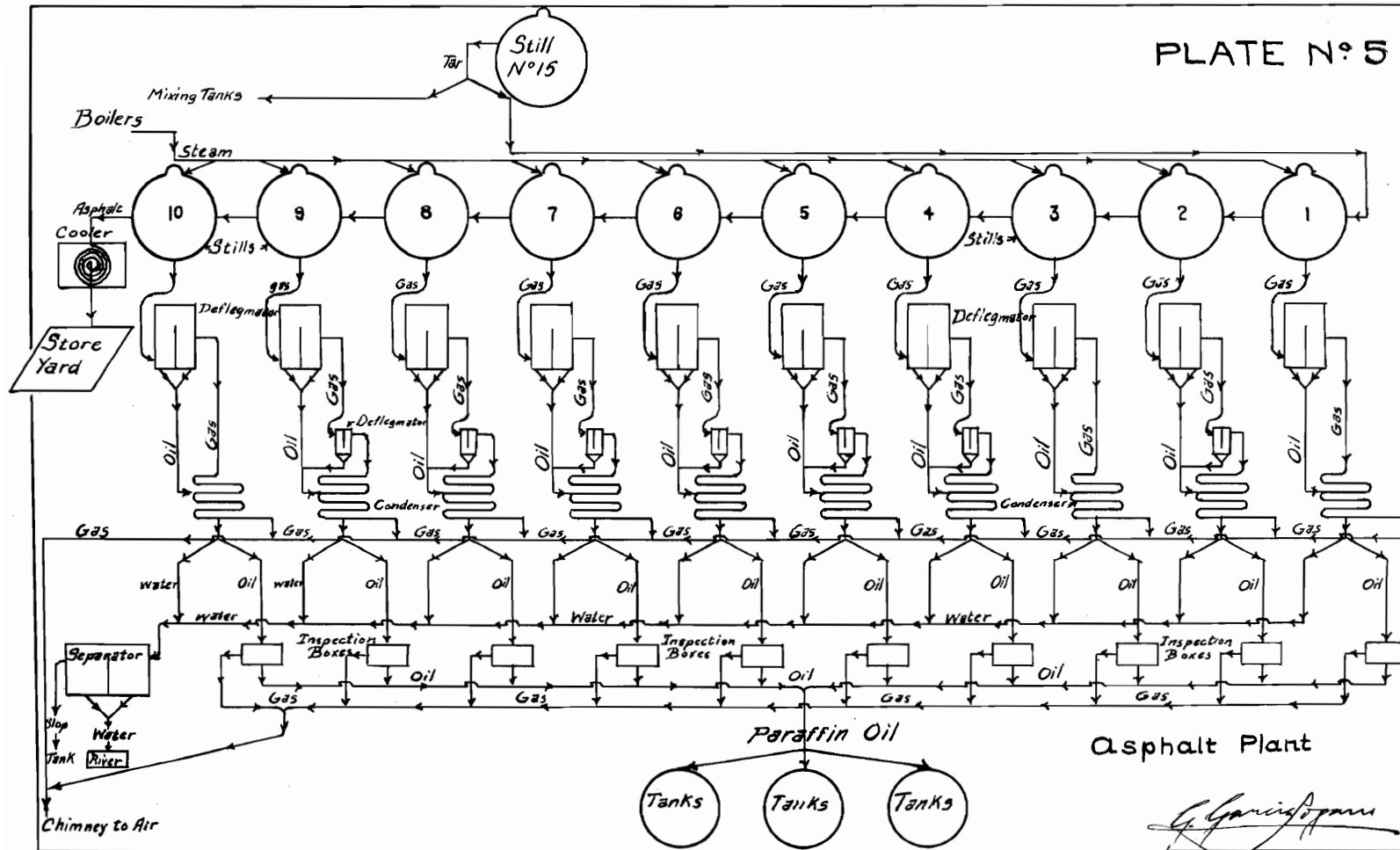
ASPHALT PLANT  
DISTILLATION UNIT



to empty the still. The steam pipe line (D) passes over the stills and is connected to them by two parallel two inch tubes situated on top and in front of the still. Each still is provided with a pyrometer placed in front and at the bottom which shows the temperature of the tar inside.

The deflegmators (see plate 4) are cylinders divided diametrically by an vertical iron plate. This plate is tight on the bottom but leaves an empty space on the top to allow for the circulation of gases. The two 12 inch tubes which carry the distillates from the stills, are connected to the lower side of one of the divisions of the deflegmator; the distillates go over the partition and leave the deflegmator by the 6 inch outlet which is on the other side. The oil which has been carried mechanically by the distillates is collected by the iron plate and together with the distillates that are condensed in the deflegmator go out thru two 2 inch pipes which are at the base of the deflegmator and on each side of the iron plate. These two short tubes are connected to a pipe which carries the oil collected in the deflegmator to be cooled in the condenser. The distillates and steam pass to a small deflegmator (see plate 4) which is similar to the larger one but inverted; the oil collected in this deflegmator is joined to the oil from the other deflegmator. The distillates together with the steam go to the big coil of the condenser. The distilling sets No. 1, 3, and 10 have only the large deflegmator, which are 3.50 mts.

PLATE N° 5



high and 1.50 mets in diameter; the small deflegmators are 1.25 mts. high and 0.60 mts in diameter. The condensers of this plant are similar to those of the crude continuous stills, with the difference of having two coils instead of one; one of the coils being for condensing the distillates, which is the same as those of the crude stills, - and another coil which is used for cooling the oil collected by the deflegmators; this smaller coil starts where the distillates are already condensed in the other coil. Here the two coils are connected with a small tube. The water - condensed goes to the bottom of the large coil, the oil being lighter remains at the top of the coil and flows over to the smaller coil going together with the oil collected - by the deflegmators to the inspection boxes. The small - coil is all of four inch tubes and goes around the condenser 4 or 6 times.

All the water condensed in the large coils of the - condensers is collected by a pipe line which carries the water to a pair of separators where the small quantities of heavy oil are separated from the water. The oil collected in the separators is called "slop".

The distillates from the asphalt plant are dirty - paraffin oils and are called in the refinery second grade paraffin oils. Their Sp.Gr. is as a rule 0.92. This paraffin oils are stored separately from the one obtained from the crude stills.

From the tar treated in the asphalt plant, all the lighter fractions have already been removed in the crude

continuous stills; it contains only some paraffin oils to be distilled off and therefore it is not necessary to vary the temperature in the different stills that form the series of continuous of the asphalt plant. On the contrary, as the principal object is to make asphalt by increasing the density and viscosity of the tar produced as a residuum from the crude stills, it is only necessary to keep the tar at a temperature of from 600° to 700° Fahr in order to continue the distillation of the heavier constituents of the oil. The time which it takes the tar to flow thru all the stills is sufficient to distill all the oil necessary to change the tar into asphalt. From the tar treated, 59 to 60 per cent of asphalt is obtained and 35 to 45 per cent of distillates, there being a loss of 5 per cent due mostly to permanent gases and heavy oil which goes with the water to the separators.

The percentage of asphalt obtained from the tar varies with the kind of asphalt made, resulting more soft asphalt than the hard one which contains less distillable constituents. The characteristics of the different kinds of asphalt made are as follows:

	Sp.Gr.	Temperature at 77° Fahr	
		Penetrability Dow	Ductility Dow
-----			
Soft	1.01	60	100
Medium	1.03 to 1.05	45	20
Hard	-----	25	20 at 160° Fahr.
Very hard	1.10	7	

Asphalt solidifies at a temperature of 160° Fahr and at this temperature it is packed in barrels of a 170 Kgm. gross weight; this barrels have a capacity a 37 gallons and weigh 9 Kgm.

Annexed to the asphalt plant is a small laboratory for the purpose of determining the properties of the - samples obtained from the stills to see if the asphalt is as specified. It is provided with apparatus Dow for ductility and penetrability tests, and cups for solidification test. Annexed to the asphalt plant is also a storage tank and a pumping station for distributing the asphalt.

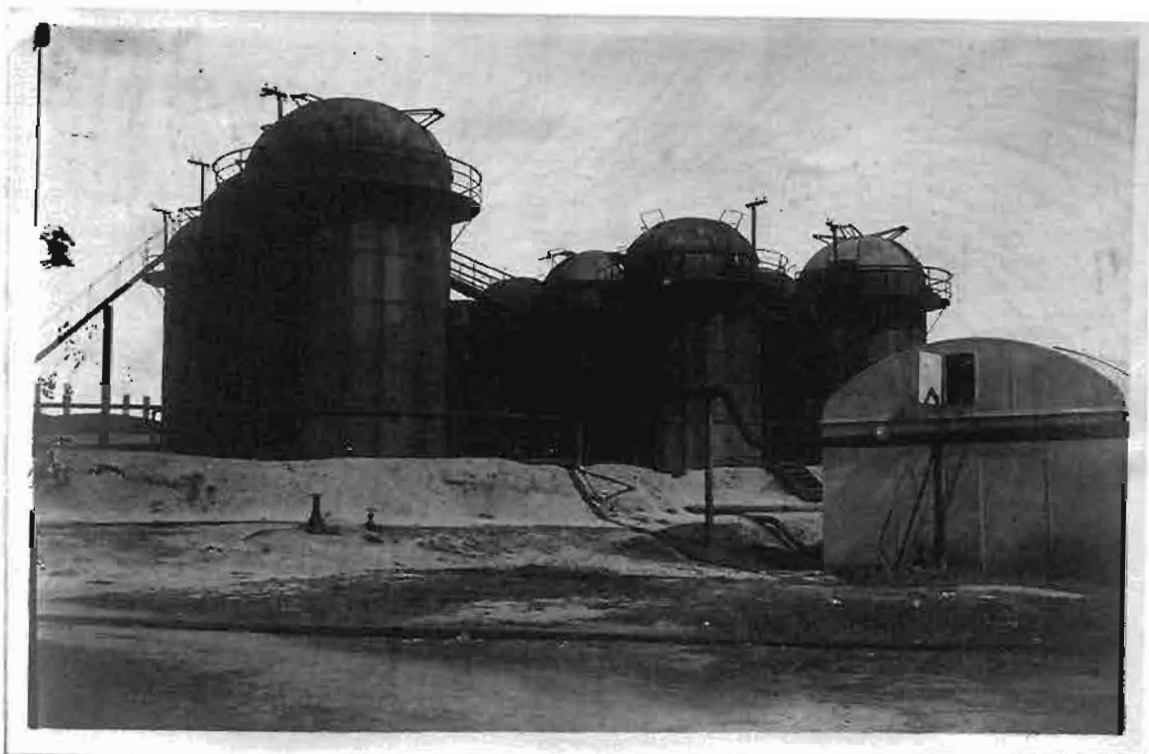
The asphalt plant consumes in fuel and steam 10 to 11 per cent of the value of the asphalt produced. The steam is supplied by two Babcock and Wilcox boilers. The plant is under the direct care of the Superintendent and its shift is composed of a still foremen, an assistant, a fireman and a sampler.

#### STEAM STILLs FOR NAPHTHAS:

The crude naphthas after being purified in the agitators, pass to the steam still to obtain a better fractional separation of the kerosene and gasoline it contains and which were distilled together in the crude continuous stills. Since the gasoline is distilled at a low temperature, fuel cannot be used to play directly on the stills as this would cause necessarily the distillation of large quantities of kerosenes. Steam is a more convenient heating agent being able to furnish it at a uniform temperature - obtaining in this way purer fractions. The system used - consists in letting the steam escape into the crude naphtha, serving the steam this way not only as a heating agent, but also to carry away the distillates as soon as they are



STEAM STILLs FOR NAPHTHAS



AGITATORS

formed. The steam is used at a pressure of from 70 to 80 pounds and at a temperature of  $170^{\circ}\text{C}$ . (it is at a lower temperature when it escapes into the gasoline).

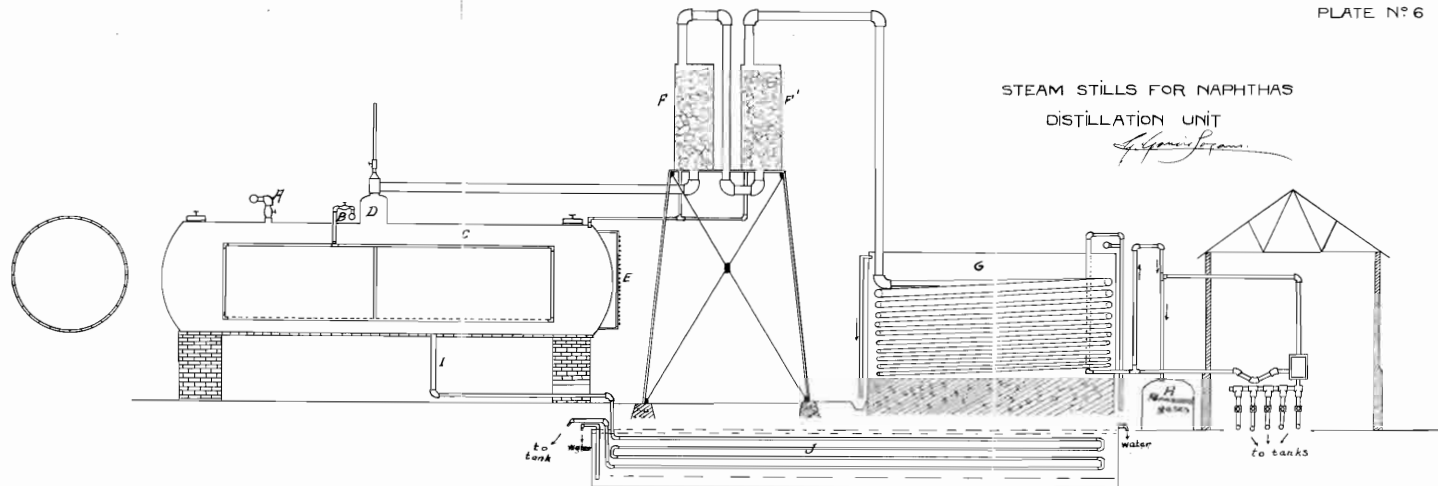
The plant is composed of nine cylindrical horizontal stills, mounted on brick walls and placed one besides the other; they are of 1,000 barrels capacity and are filled to two feet from the top; they are lined with brick to avoid radiation of heat. There is a steam main pipe line and a feed pipe line for the nine stills; each still has two deflegmators, a condenser and an inspection box.

As a rule only two products are made in this plant, gasoline and kerosene; the first is obtained as a distillate and the second as a residuum. The process is as follows: The stills are charged up to 9 or 10 feet deep with crude naphtha pumped direct from the agitators to the feed pipeline (A) (see plate 6) Heating is started with steam supplied from main (B) and is distributed in the inside of the still by means of a tube grate (C) similar to the one described for the crude stills.

The steam together with the gasoline goes out by dome (D) thru a 12 inch tube which carries the distillates to the deflegmators. By regulating the quantity of steam, the amount of distillates produced can be kept uniform during the process, taking care that there should be no pressure inside the stills. There is in front the still one and 1/2 inch vertical tube (E) connected to the lower and upper part of the still, and by means of small cocks placed 15 cm. apart the level of the oil which is being distilled, can be

STEAM STILLS FOR NAPHTHAS  
DISTILLATION UNIT

*Alfonso Lopez*





ascertained. The distillates go to the first deflegmator and enter it by the bottom; leaving there in the bricks with which it is filled, all the kerosene which has been carried mechanically. The distillates go out by the outlet in the upper part and go to another deflegmator (F') equal to the first one. After receiving the final scrubbing in this deflegmator, the distillates go to the condenser. - The deflegmators have in their lower part an outlet for the oil that is collected by the brick and that drips - down to the 3 inch tube thru which they are returned to the stills. The most important role of the deflegmators in this department, besides collecting the kerosene that is carried mechanically by the distillate, is to condense the kerosene of low boiling point which is distilled - together with the gasoline. Nevertheless, the sun heat of this latitudes hinders the deflegmator from producing the effect desired as the temperature acquired by the steel plates with the sun soon distill again the kerosene. This happens only in this department where the distillates are of relatively low temperature.

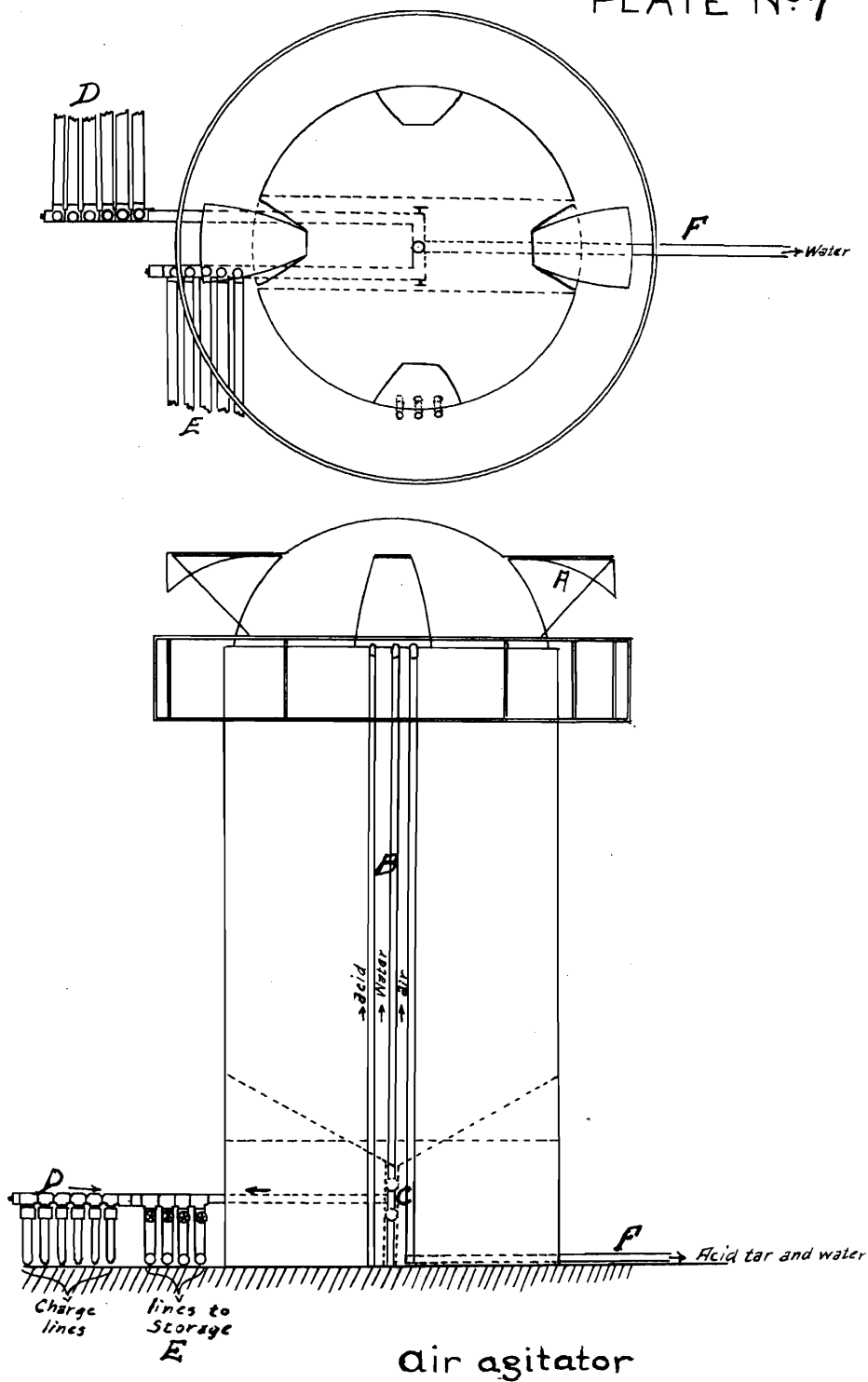
The condensers (G) are equal to those of the crude continuous still units. They have only one coil of 11 - rounds; 2 rounds are of 10 inch tubes, 3 of 8 inch, and 4 of 6 inch tubes. They are not provided with pressure nor vacuum valves. At the back of the condensers is a tube - which collects all the permanent gases and carries them to a drum (H) from where they go to the chimney. The nine inspection boxes are arranged to distribute the distillates to five storage tanks.

When the temperature of distillation has reached  $120^{\circ}$  or  $150^{\circ}\text{C}$ . (depending on the class of gasoline that is being made) the operation is stoped, the steam valve is closed and the residuum which is kerosene, is let - out thru a 4 inch pipe (I) and taken to two coolers (J) from where the kerosene is stored beford going to the agitators. The coolers are long troughs with water, 18 mts. long and 0.80 mts broad where water flows in the same manner as in the condensers; the kerosene is cooled by flowing around three coils; the coolers being used in series or separatly. The treatment for each charge lasts 48 hours in this department.

The fractions are separated by means of the distillation temperature, being this method more exact and follows closer the operation done in the laboratory where the fraction corresponding to each charge to be treated in th steam stills, are determined in this way.

The products obtained vary somewhat in class. Good gasoline is distilled to a temperature of  $120^{\circ}\text{C}$ ., at the most  $150^{\circ}\text{C}$ . and has Sp. Gr. of from 0.715 to 0.720. The second class gasoline has a SP. Gr. of 0.750. The first class kerosene has a Sp. Gr. of from 0.798 to 0.795 - with a high flash piont. The second class kerosene has a Sp. Gr. of from 0.790 to 0.795 and has a low flash - point. Besides the first class kerosene is given a finer treatment in the agitators resulting a safer and cleaner illuminant.

Sometimes from the first framction distilled from the crude naphtha bencine is made.



Air agitator

*G. Garinfogues.*

The shift for this plant is composed of only one - still foreman who has in charge the work of the nine - stills, condensers and inspection boxes.

#### AGITATORS:

In the agitators the gasolines, kerosenes, lubricants and sometimes the gas oil receive a purifying treatment - consisting in a chemical process, where the reagents are sulphuric acid and alcaly (sodium hydroxide) The object of this treatment is to remove from the oil the bad odor and colour which impairs the lubricants kerosenes and - gasoline. The chemical reaction which takes place is most probably one of eliminating or decomposing the aromatic hydrocarbons, acid or fatty substances, tarry products and principally (for the Mexican oils) the sulphur compounds.

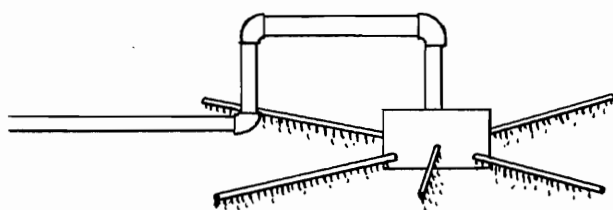
The agitators do not form a deffinite step in the general process of refining but on the contrary, its use is distributed in many of the steps which follow the - different products made by the refinery. With the exception of the paraffin-wax which is purified in especial agitators, the crude and re-distilled naphthas and illuminants and - lubricants in the different stages of their making, receive various treatments of purification in this agitators, and even the gas oil is washed once and often more times in - the agitators.

The chemical treatment is divided in two parts; the acid treatment and the alcaly treatment. In a large refinery it becomes necessary to have separate agitators for the acid and for the basic treatment; in this way not only time is saved but also the number of agitators with lead

lining is reduced, as it is not necessary for the agitators used for the alkali treatment; besides better results are obtained. Agitation is accomplished with compressed air.

There are three agitators for the acid treatment - lined with lead of 1,300 barrels capacity each and 8 of 500 barrels capacity for the basic treatment some of which are also lined with lead.

The agitators are vertical cylinders with conical bottom and a vault roof. They can be closed completely to avoid losses of evaporation when light oils are being agitated. The vaults have four doors (A) (See plate 7) which are opened and closed by means of a pulley suspended from a frame. One of the three tubes (B) is the air line; it descends in the inside to the bottom of the cone where the air comes in contact with the liquid to be agitated. The water line ends in the central part of the vault with a rose-nozzle. This rose-nozzle is formed of six two inch



Rose-nozzle

tubes and serves to spray the wash water uniformly in the agitator. The third tube is for the chemical agent. The agitators where the lubricants are treated have in the lower part 5 steam

coils for heating the oil to the required temperature.

To the vertex of the cone is connected a three-way branch pipe in cross (C). Thru one of the horizontal connections of the cross enter the oils that are to be purified and is connected in turn to six pipe lines (D);

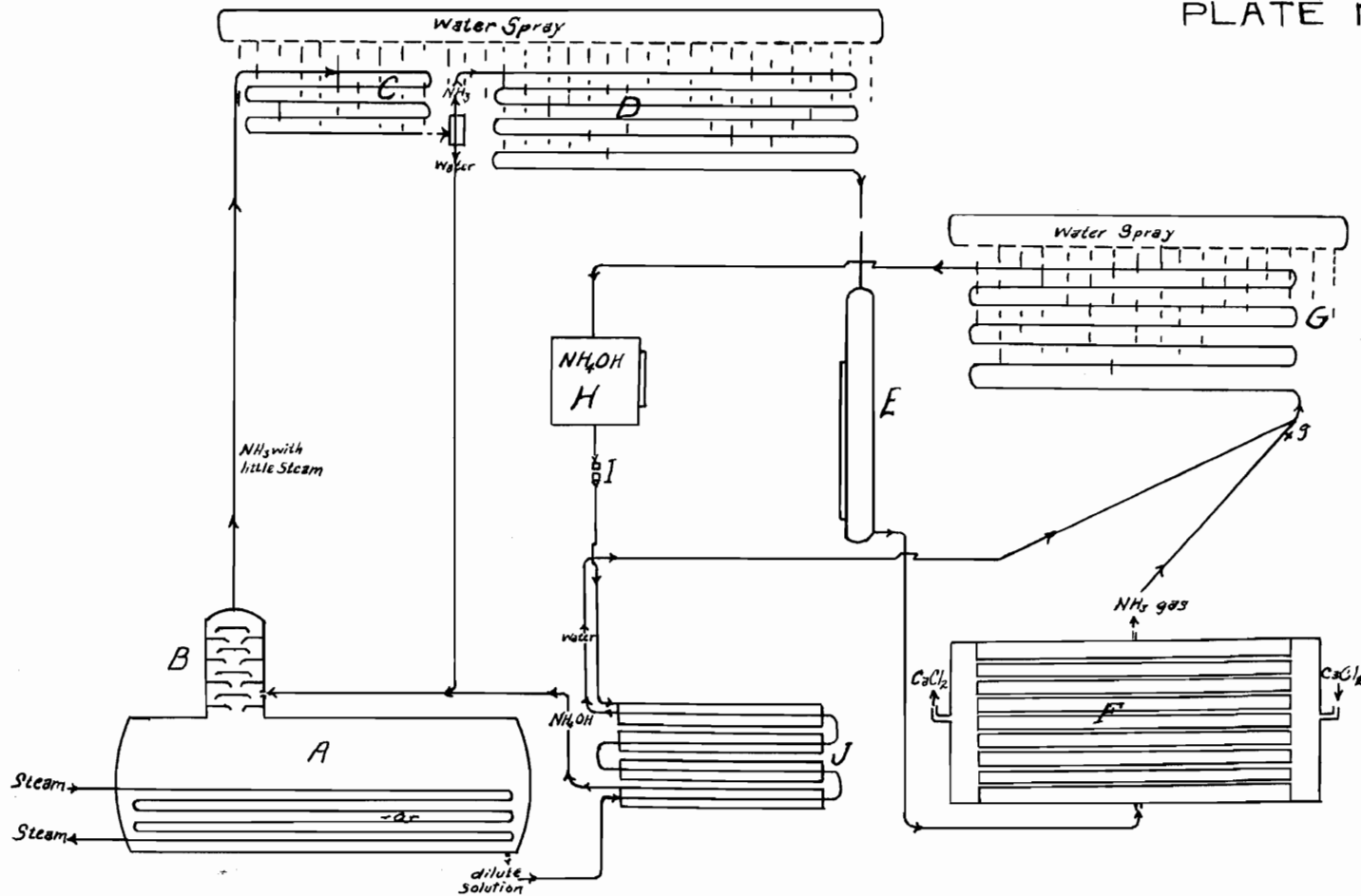
thru the other horizontal branch, go out the purified oils and is connected to four pipe lines (E) which carry the oil to the storage tanks. The impurities and water which collect at the bottom of the cone go out thru tube (F). The refinery recovers the acid from the asphaltic-acid.

Three pairs of small agitators are provided with a Worthington pumps, which are used to move the oil of one agitator directly to the other.

The compressed air is furnished at a pressure of 60 lbs.

The acid for the agitators is placed in horizontal cylindrical tanks of 1 mt. in diameter by 2 mts. long to which is applied compressed air to charge the agitators with the required quantity of acid.

Due to the fact that not only do all the distilled products of the refinery receive the last treatment in the agitators, but also receive intermediate treatments, the variety of the charges is great and consequently the percentages of acid and alcaly, the required<sup>time</sup> for agitation, the temperature at which the oil must be kept during agitation, and the quantity of air, vary greatly. Therefore for each charge an especial process is prescribed by the laboratory. Due to the high contents of sulphur in the Mexican crude oils the amount of sulphuric acid required is some times as high as 10% of the volume of oil. (For general principles of purification of mineral oils see "Das Erdol" "by Dr. Vert", "Treatise on Petroleum" by Redwood Vol.2, page 27 "Treatise on Mineral Oils" by I.I. Redwood page 125 and 203 to 210)



Absorption System Refrigerating Machine  
Paraffin Wax Plant

*G. Garciapagos.*

### PARAFFIN WAX PLANT.

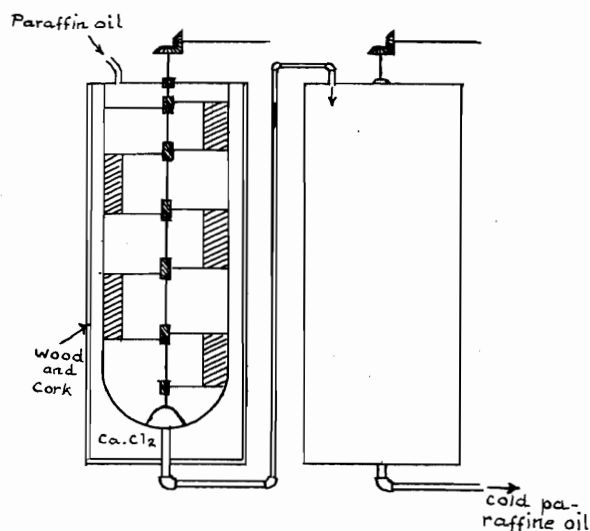
The paraffin wax plant treats the heaviest fraction distilled from the crude oil; to this fraction has been given the name of paraffin oils. These are first purified in the agitators. The paraffin oils derived from the asphalt plant before going to the agitators are re-distilled to remove from it the asphaltic impurities which give it the dark color and which clog the canvases of the filter-presses. The paraffin wax plant separates the paraffin from the gas oil and lubricating oil.

This plant is composed of a refrigeration department with coolers, filter-presses, the liquid ammonia generator and the necessary pumps; four "sweating" chambers for refining the paraffin, and the mold and agitators department where the paraffin is purified and packed. The paraffin plant has besides, a storage tank for paraffin oil and six for paraffin wax and also an ice plant. All the buildings are brick frame structures with corrugated iron roof.

The refrigeration department consists of a liquid ammonia generator, a cooler for the calcium chloride solution, two vertical coolers for the paraffin oils, three horizontal filter-presses and seven triplex pumps used for the distribution of the paraffin oil, paraffin, and filtered oils. As each of the parts of this department needs a different temperature they are in separate rooms. The power needed by the plant is furnished by a Babcock and Wilcox boiler which moves a 100 HP. horizontal Allis Chalmers engine. The power of this engine is transmitted by belts



to the pumps and machines of the department. The paraffin oil is first allowed to rest in a 30 feet high tank of 3000 barrels capacity to remove the water from it. By

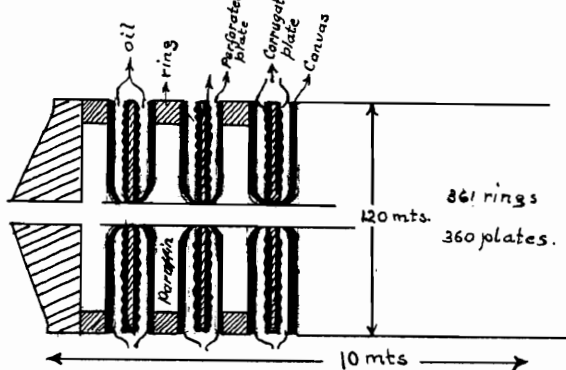


Vertical cooler

means of a vertical triplex pumps, the vertical coolers are charged. These are about 5 meters high and have a capacity of 50 barrels each, they are lined with wood and cork, and the cooling agent is the calcium chloride which surrounds the tank; it is provided with an agitator inside, which scrapes the wall of the tank. The cold calcium chloride solution is obtained from the refrigerator. The two vertical coolers work in series, the first one cools the paraffin oil to  $10^{\circ}\text{C}$ . and the second to  $0^{\circ}\text{C}$ . Two vertical triplex pumps of a capacity of 34 barrels per hour pump the paraffin oil to the horizontal cooler. These pumps work in series and give the oil a pressure of 350 to 400 pounds which is required for the filtering operation. The filter-presses only need 350 pounds pressure, but 50 pounds are lost in passing the oil through the horizontal cooler. The horizontal cooler consists of a coil formed by 12 tubes which have a smaller tube inside; the exterior tubes are about 6 inches in diameter and the smaller are 4 inches in diameter. The calcium

chloride solution moves in the exterior tube and cools the thick paraffin oil which moves in the interior tube helped by a worm. The capacity of this cooler is of 15 barrels and cools the paraffin oil to  $4^{\circ}\text{C}$ . below zero. The paraffin oil enters the filter-presses with a pressure of about 350 pounds per sq.in.

The filter presses are made of a series of rings and corrugated plates; this plates having on the sides a metal strainer, plates and strainer being covered with canvas. The filter presses are 10 mts. long and 1.20 mts. in diameter. Each press has 361 rings 10 mm. thick and 360 corrugated plates, each having two strainers and a

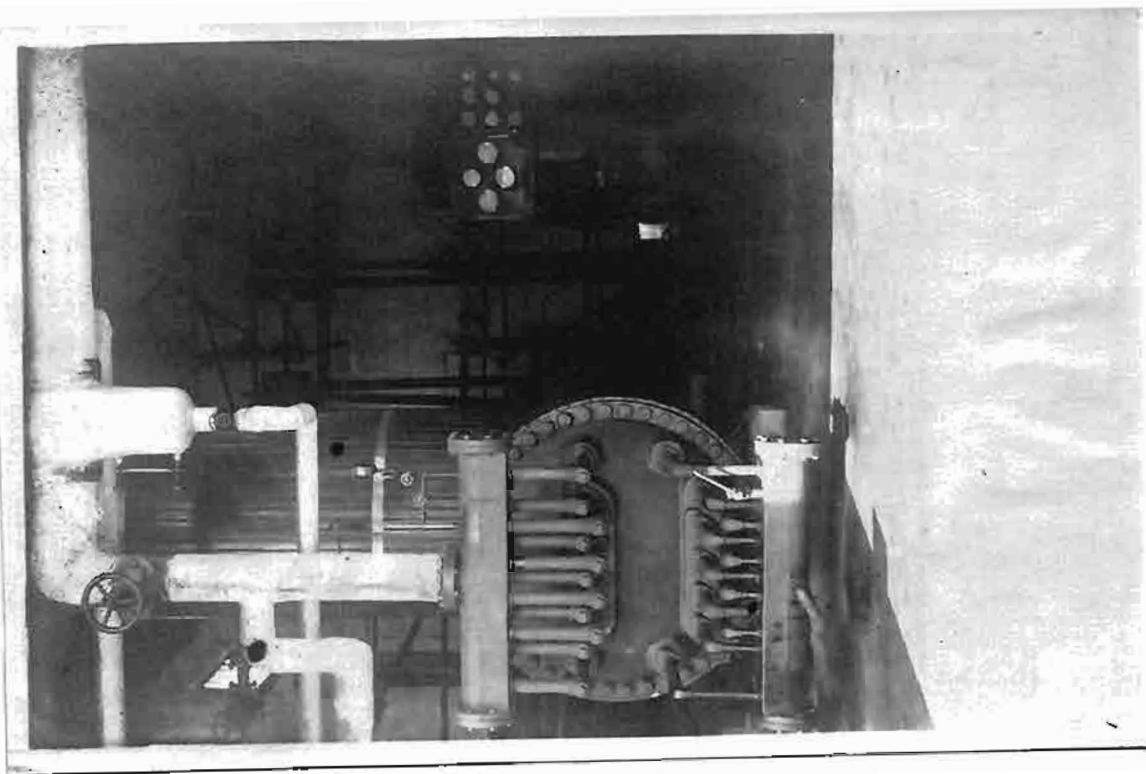


canvas covering, altogether being 12 mm. thick. The hole in the center of the plates for the passage of the paraffin oil is 3 cm. in diameter. The paraffin

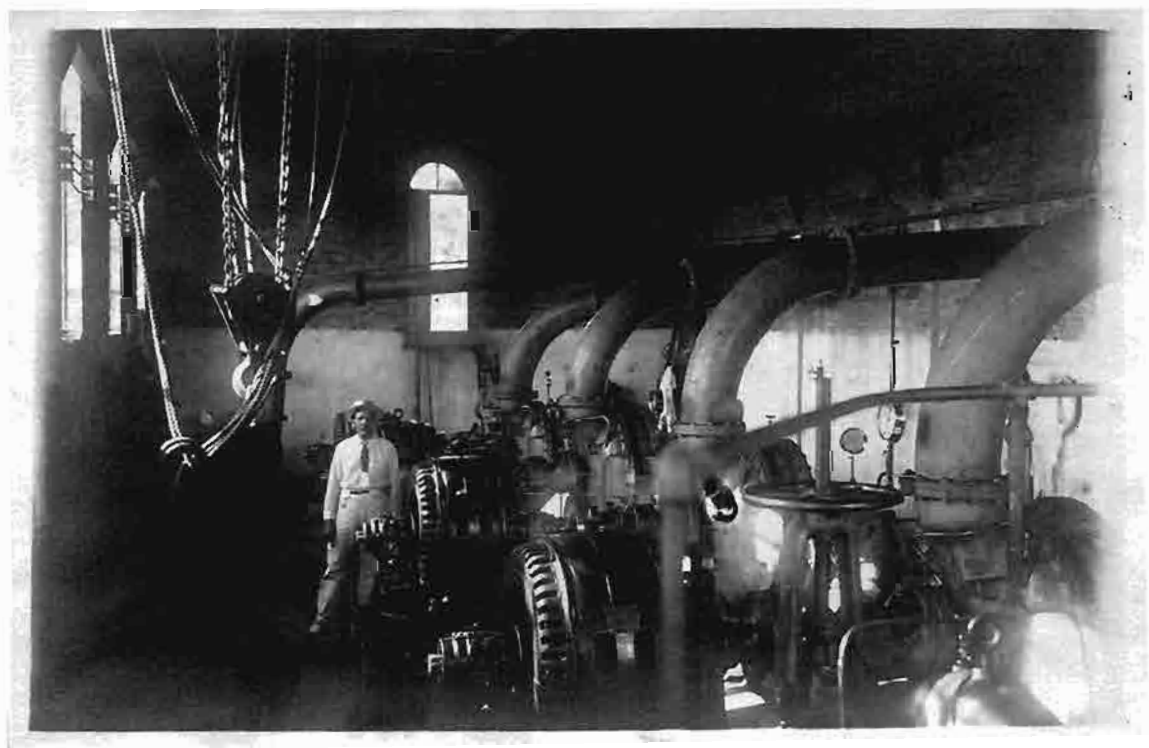
is crystalized in the empty space between the plates formed by the rings, while the oil is filtered thru the canvas, passes thru the holes of the strainer and flows in the corrugations of the plate and leaves the press by the side outlets. The presses are provided at one of the extremities with a hydraulic press which keeps tight the plates, strainers, canvas and rings, and also serves to remove the head of the filter-press when the filtering operation is finished. To separate the paraffin from the filter the plates and rings must be removed one by one.

At the bottom of the filter-press is a worm-conveyor which collects all the scrap paraffin. The paraffin is fused and pumped to a tank where the water and impurities are removed from it. From this tank the paraffin passes to the "sweating" chambers.

The refrigerating machine is of the absorption system manufactured by the Carbondale Co. The principle of the absorption process of refrigeration consists in the separation of the ammonia gas from the aqua ammonia by means of heat. The gas is condensed to a liquid by pressure and cooling; the liquid ammonia is evaporated its heat being absorbed by the calcium chloride solution and the gaseous ammonia is absorbed again by water, forming again the initial aqua ammonia. The aqua ammonia is heated in the generator (A) (see plate No. 8) by means of a steam coil (a); there is a deflegmator (B) which returns the water carried mechanically by the vapors to the generator, - allowing only the water and ammonia vapors (which are no longer in solution) to go out. The vapors which are under a pressure of 180 lbs. pass first thru a small condenser (C) where by means of a water spray the water vapor is condensed and separated from the ammonia gas. The ammonia gas goes to a larger condenser (D) where it is cooled to the temperature of the spray water; the critical point of ammonia gas at a pressure of 180 lbs. being  $26^{\circ}\text{C}$ . it liquifies. The liquid ammonia passes to tank (E) where it is stored, from where it flows thru the expansion valve to the vaporizer (T). The vaporizer is constructed like a steam tubular



REFRIGERATING MACHINE  
IN THE REAR ARE SEEN THE GALVANOETRIC THERMOMETERS



WATER PUMPING PLANT

boiler; the calcium chloride solution flows thru the tubes, while the evaporation of the liquid ammonia takes place in the empty space between the tubes. From the vaporizer the ammonia, now in the gaseous state, flows thru the valve (g) into the absorber (G) which receives weak ammonia solution from the generator. The absorption of the ammonia gas by the weak solution in the absorber generates heat, which is carried off by the cooling water of the spray. The strong liquor thus formed in the absorber goes to tank (H) which has a device for governing the operation of the pump (I) which delivers the aqua ammonia to the generator thru the outer space in the regenerator coil (J). The weak solution from the generator is transferred to the absorber thru the inner coil of the regenerator; consequently the liquid entering the generator is thus heated while that entering the absorber is cooled. The function of the regenerator is, therefore, to economized heat by transferring the heat from the weak to the strong liquor. It is obvious that any heat transmitted from the weak to the strong liquor represents just so much gain in economy. As the only power required by the absorption system is that necessary to circulate the various liquids, it is inconsiderable when compared with that required by the compression system. Usually the exhaust steam from the steam engines furnishes sufficient heat for the operation of the plant. The amount of cooling water, however required by this system is greatly in excess of that required by a compression plant of the same capacity. This refrigerating machine has a capacity of 500,000 calories per hour and needs 500 gallons of water

per minute for its coolers and condensers.

The refrigerating department has 12 galvanometric thermometers which register the temperature of the different parts of this department.

The refining department consists of four "sweating" chambers; each being a separate building. Each chamber has two iron frames holding 24 pans between the two. These pans are 2 X 8 meters and 14 cm. deep. They are filled with water up to a thick wire gauze placed at about 5 cm. from the bottom. The paraffin is poured on the wire gauze, and when it is solid, the water is let out from the bottom. The doors and windows are closed and the chamber is warmed with a steam radiator which surrounds the room. The temperature is increased slowly so as to make the oil "sweat" out of the paraffin. This oil is viscous, and to make it flow out of the pan it must be inclined; this is done by inclining the frame which rests only at the center on the edge of an iron plate; this allows the frames to be inclined a little. The temperature is increased to 80° or 90°C; and to remove the paraffin which remains in the pans, steam is blown thru a tube which is on the bottom. The "sweating" chambers produce paraffin oil, three kinds of paraffins with varying amounts of oil and transparent paraffin. To separate the four kinds of paraffins it is necessary to sample periodically the paraffin as <sup>it</sup> is being fused. The oil first separated is distilled and the intermediate paraffins (third, second and first) are solidified and fused again in the sweating chambers (see flow sheet).

In the "sweating" chambers it is done to the crude paraffin what is done to the crude oil in the stills; the only difference is that in the stills the crude oil is subjected to fractional distillation, while in the "sweating" chambers the process is one of fractional fusion. The refining treatment given to the paraffin is also analogous, re-fusing the fractions to separate from it the pure paraffin and the oil. From the first fusion (see flow sheet) result from 30 to 35 per cent oil and 10 per cent 120°C. transparent paraffin; the second fraction is composed of 30 per cent or less of oil and 20 to 30 per cent 123°C paraffin; from the third fraction results 20 per cent oil and from 30 to 40 per cent 125°C paraffin, and from the last fraction is obtained 5 to 10 per cent oil and 40 to 45 per cent transparent paraffin which has a fusing point of 130°C. The paraffin is first heated in a storage tank before going to the agitators.

The paraffin is purified in two stages; the first treatment is done in an acid agitator where water, some sulphur compounds and other impurities are removed; the second is done in an agitator with Fuller's earth which bleaches the paraffin and removes from it the excess acid which may have resulted from the previous treatment. The agitators are of 150 barrels capacity and with a conical bottom; agitation is done with air, and they are charged from the top with paraffin and the necessary chemical agents. The paraffin and the impurities that are separated from it, are taken out from the bottom of the cones. In

the acid agitator, the first portion added to the paraffin is two per cent of the volume of paraffin; this separates the water and requires agitation for 15 minutes. The acid water is then removed from the bottom; six per cent of acid is next added and the charge is agitated 25 minutes obtaining most of the removal of the impurities which are drawn out from the bottom. The last treatment in the acid agitator is done with two per cent acid and agitated 30 minutes removing all the impurities that may have remained leaving in the paraffin an small excess of acid. The length of time required for each acid treatment may vary, but as a rule for all cases, the acid purification lasts 70 minutes. The separate amounts of acid added may also vary, but the total amount required is about 10 per cent of the volume of paraffin, taking care always that the first and last portions be small. The acid agitator is lined with lead, the other one does not need it. The paraffin has been cooled slightly in the acid agitator and must be warmed up again. For this purpose the other agitator is provided with a steam coil which warms the paraffin to 100°C. The paraffin is mixed with three per cent its volume of Fuller's earth and is agitated for two hours to neutralize the excess acid and to bleach the paraffin. A small duplex pump, pumps the contents of the agitator to a filter-press, where the paraffin is filtered and the Fuller's earth with 50 per cent paraffin remains as a filtrate. This filter-press is similar to the one used to separate the paraffin from the oil.

The paraffin is now in a marketable condition and is



stored in a 150 barrel capacity tank before being poured in the molds. The mold department consists of four racks, three with 150 molds each and one with 100 molds. Each mold makes a paraffin block of 5 Kgm. The paraffin requires 12 hours for solidifying and cooling. This time may be shortened by putting the molds in ice water. A system of press molds is being experimented but is not yet definitively in use.

The paraffin wax plant makes three kinds of paraffins, class "B" which melts at  $123^{\circ}\text{C}$  and is made by mixing paraffins which melt at  $120^{\circ}$ ,  $123^{\circ}$  and  $125^{\circ}$ ; class "C" which melts at  $125^{\circ}$  and is made by mixing paraffins which melt at  $123^{\circ}$ ,  $125^{\circ}$  and  $130^{\circ}$ , and class "E" which is the best, melts at  $130^{\circ}$  and is worth about 50% more than the others.

The plant is managed by a chief, an assistant and a master mechanic. The employees needed for the three shifts of the day are four foremen, three men for the ice plant, four measurers, three for the sweating chambers and three for the agitators; eleven men do general work around the plant and twenty work during the day only, in the store and mold department.

The ice plant has a capacity of 9,000 calories per hour, and makes 122 ice blocks of 50 kgm. each a day.

#### LUBRICANT PLANT.

The oils filtered from the filter-presses in the paraffin plant, still contain gas oil, some times as much as 70 per cent. This makes it necessary to treat the oil

in the re-distillation stills to remove as a distillate the gas oil, leaving as a residuum the lubricating oil that is to be treated in the lubricating stills. Some light lubricants are often distilled also as a fraction following the gas oil. The oils are first purified in the agitators before going to the lubricant plant. This plant is one of the final steps of the refinery the products resulting from here only requiring the last treatment in the agitators to put them ready for the market.

This plant consists of 7 stills of 260 barrels capacity each. They are placed on four pairs of furnaces (the last furnace has only one still), there being a chimney for each pair of furnaces. These stills are the same as the ones described for the asphalt plant. Each unit consists of a still, one large deflegmator, a condenser with two coils and an inspection box; each of these apparatuses are the same as the corresponding ones of the asphalt plant. Each condenser is provided with two vacuum apparatuses which have a water injector device. The object of making vacuum in the stills is to avoid the accumulation of distillates by removing them as soon as they are formed. All the oil is condensed in the deflegmators and the condensers only serve to cool the oil, the gases removed by the vacuum apparatus being only permanent gases. This plant has a steam superheater and a cooling tank with coils for cooling the residuums.

The process of this plant is intermittent. If the oil has some water it is first warmed slowly to evaporate all the water. Then the temperature is increased rapidly until

the distillation of the gas oil starts. The temperature is increased to distill the heavier fractions until the desired residuum is obtained when the operation is stopped. Air is used inside the stills instead of steam when an especial kind of asphalt is desired. The characteristics of the fractions obtained as distillates and residuum in this stills, varies considerably due to the many kinds of lubricants that are made in the refinery and that every charge is different, each charge being one of the fractions from the re-distillation stills which also vary considerably. Therefore, this stills do not follow a general process, but follow the indications which for each charge is prescribed by the laboratory, and doing with them in a large scale what has been determined in the laboratory with similar but smaller apparatus. This stills make, from the best asphalt manufactured by the refinery to the light, odorless and colorless lubricant which is also used as a purgative. A detailed description of the process followed in the lubricant plant would require a description of the especial process applied to make each of the 25 kinds of lubricants made by the refinery, for which study I did not have sufficient time.

#### TREATMENT OF THE TECUANAPA CRUDE OIL.

The Tecuanapa oil field is in the South of the State of Veracruz on the right hand border of the Uspanapa river which is an affluent of the Coatzacoalcas river. The Tecuanapa crude oil is a very different kind of oil from that produced in the Tuxpan oil field and from any other

oil field of the Republic as can be seen from the following fractional distillation analysis of a sample of Tecuanapa crude oil.

Naphtha.....	8%
Illuminating oil.....	39%
Gas oil.....	10%
Lubricating oil.....	34%
Asphalt.....	4%
Sulphur.....	1%
Loss.....	4%

The small amount of asphalt and the large amount of lubricating oil this oil contains, would make it a good lubricant in its natural state if it was not for its high percentage of gasoline and kerosene which give it a very low flash point. Due to the good quality of this oil it is given an especial treatment, not only in what concerns the process but also in that a separate still, pipe lines and storage tanks are only used for treating this oil.

The water is separated from the crude oil in the storage tank. From here the crude oil goes to a 1000 barrel capacity still equal to those of the continuous stills for crude oil (see plate 2) with the only difference that it is used intermittently. When distillation starts the temperature is being increased so as to obtain a uniform flow of distillates in the inspection box, separating the different fractions as they come out by means of the manifold arrangement of valves. The oil is distilled until the residuum is asphalt or coke, the fractions distilled being naphtha, kerosene, gas oil and paraffin oil. Each of the fractions is treated in a similar way to the corresponding ones of the continuous distillation stills.

#### RE-DISTILLATION STILLLS:

The crude kerosene which is the second fraction distilled in the continuous stills, needs not only to be purified in the agitators but it must be also re-distilled to remove from it the gasoline which distills together with the kerosene in stills No. 4 and 5 (see plate 2) as also the gas oil which is carried mechanically by the kerosene, or that is distilled together with the heavier kerosene in stills No. 8 and 9. The kerosene which is left as a residuum in the steam stills for gasoline, contains gasoline (especially if first grade gasoline has been distilled) and must be re-distilled to remove the gasoline which gives the kerosene a low flash point. The paraffin oil contains large amounts of gas oil and to separate it from the lubricating oil, it is necessary to re-distill the oil which results as a filtrate from the filter-presses in the paraffin plant. The paraffin oil produced by the asphalt plant contains no gas oil, but on the other hand it has asphalt which clogs the canvases of the filter-presses, this asphalt being removed from the oil by re-distillation.

The kerosenes and paraffin oils are re-distilled in seven stills equal to the continuous stills for crude oil. They all work intermittently, each having a separate outlet for the residuum. The crude oils from San Cristobal and Furber are also treated in these stills, in this case when there is a large quantity of this crude oil in store, two or three of these stills are connected together and worked

like continuous stills. Two of these stills, which are used mostly for re-distilling paraffin and lubricating oils, are provided with deflegnators.

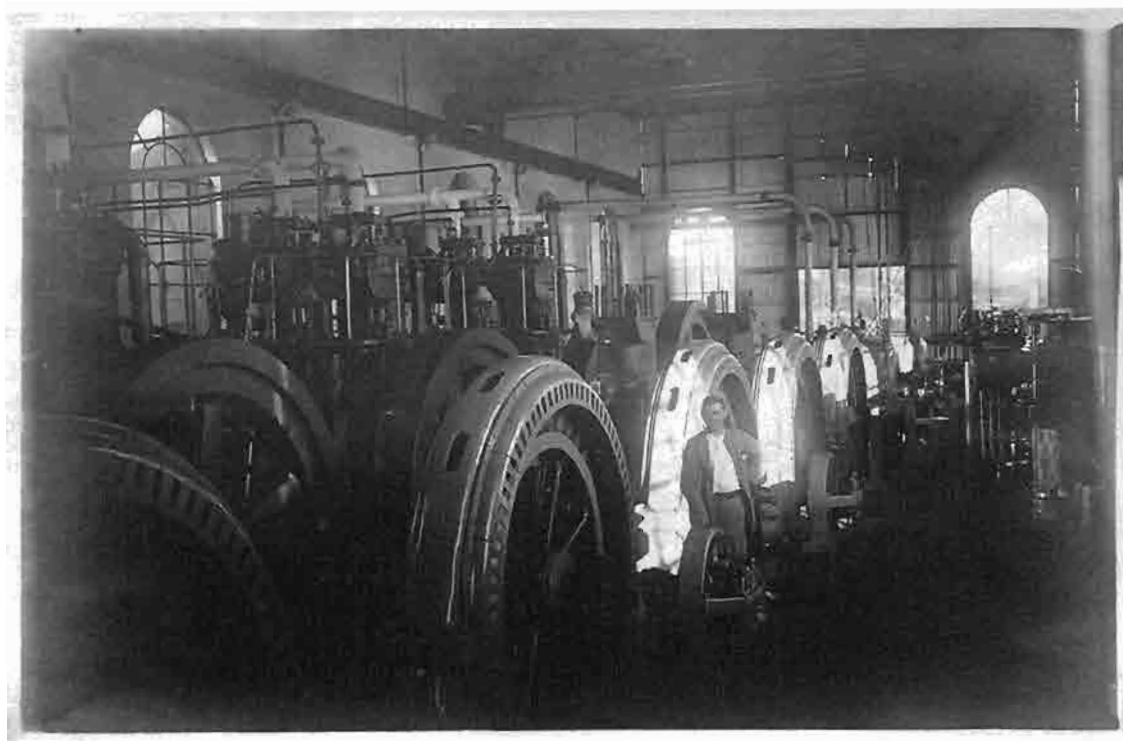
The inspection box house corresponding to these stills, contains 13 inspection boxes; three are for the first three stills of the continuous crude oil plant, one for the Tecuanapa still, seven for the re-distillation stills and two that are not in use. This inspection boxes are arranged to distribute the distillates thru 9 pipe lines.

#### SEPARATORS.

All the waste water of the refinery contains some oil, and to collect as much of it as possible there is a separator at the end of each of the waste canals. This separators are concrete tanks divided into several divisions by vertical partitions with an open space at the bottom, the water flowing from one division to the other thru this open space. As the oil remains on top, it accumulates on the upper part of each partition from where it is pumped back to the refinery. The oil collected from the separators is called "slop" and is used as fuel for the refinery.

#### WATER PUMPING PLANT.

The plant pumps the water from the river to the distributing tank of 45,000 barrels, which is situated on a hill 30 mts. high. The building is of masonry 22 mts long and 12 mts wide with an iron frame and tile roof. The walls support a moving crane. The pumps are all centrifugal pumps directly connected to A. C. induction motors of 550 volts (two are 500 volt motors) made for trifasic and 60 cycles current. Each unit has an independent automatic



ELECTRIC POWER PLANT



DISTILLATE PUMPING STATION

starter. The plant is divided into the following groups:

4- Duplex centrifugal pump units each of 160,000 gallons per minute capacity, connected to 200 HP and 860 r.p.m. motors the efficiency of this units is about 60%.

1- Centrifugal pump unit of 60,000 gallons per minute capacity connected to a 100 HP, and 1150 r.p.m. motor.

2-Centrifugal units with an air injector divide connected to 15 HP. and 1125 r.p.m. motors. This pumps serve to make the initial vacuum in the large centrifugal pumps.

The 160,000 gallons and the 60,000 gallons centrifugal pumps feed the water storage and distributing tank and work under a pressure of 50 lbs. per sq. inch due to the height of the water tank.

The suction head varies between 13 and 16 inches of mercury varying with the tide and the amount of water in the river. There are three 25 HP pumps of 1,600 gallons capacity which supply water to the condensers of the steam turbines.

The total capacity of the pumping plant excluding the pumps which supply water to the condensers, is 700,000 gallons per minute and consumes 852 KW. At this capacity the pumps work at the best efficiency.

#### ELECTRIC POWER PLANT.

This plant furnishes the power needed by the water pumps, the oil pumps, the agitators, the acid factory, the air compressors, the can and barrel factory and the light used by the refinery, its offices and dwellings.

At the begining the plant consisted of internal com-



bustion engines directly connected to A.A. and G. (Germany) generators. But as the fuel consumed by this engines is more expensive than that used by boilers and as the five generators did not produce sufficient power, three steam turbines directly connected to electric generators were installed and are now the ones that furnish all the power needed by the refinery.

The new turbine plant consists of:

3- 500 KW. units. This are composed of Curtis steam turbines which work with steam at a pressure of 160 lbs. and are connected to A.C. General Electric generators of 600 volts and 3,600 r.p.m. The turbines discharge the steam into vacuum chambers and consumes 19 lbs. of steam per KW. The generators are excited by two 15 KW, 125 volt exciters and one of 14 KW.

3- condensers each corresponding to one of the turbines. They are of the Jamesville Pump Co. and have a capacity of 12,000 lbs. of steam per hour. Each condenser is provided with a Jamesville vacuum pump 6 X 12 X 12 to remove the steam that is not condensed and complete the vacuum in the condenser. The water is removed from the condensers by means of 3 HP Worthington duplex centrifugal pumps.

3- Babcock and Wilcox boilers, one has a capacity of 10,000 lbs. evaporation per hour and the other two, have a capacity of 12,500 lbs. evaporation per hour. The larger ones evaporate 11,921 lbs of steam per lb. of fuel, the smaller one 11. 304 lbs. steam per lb of fuel.

The plant consumes from 2.1 yo 2.2 lbs. of fuel per WKH, and when slop is used it consumes as much as 2.5.

As a rule the fuel used has a Sp.Gr. of 0.985; it is filtered and warmed to 136°C before entering the burners. The water is warmed by the exhaust steam of the boiler feed pumps before entering the boilers.

The distribution of electric power in the refinery is as follows.

Can and barrel Factory.....	2150	KWH
Machine Shop.....	3810	
Acid Plant.....	21360	
Water Pumps.....	309850	
Agitators.....	8180	
Air Compresors.....	58200	
Oil Pumps.....	49300	
Plumbers shop.....	55200	
Electric power plant.....	32130	
Paraffin plant.....	4000	
Light.....	33130	

This monthly report represents well the average amount of electric energy used by the refinery. The cost per KWH is from 0.7 to D.75 cents.

The other part of the plant not in use consists of 5, A.A. G. generators (made in Germany) of 80 KW 600 Volts and 180 r.p.m. they are directly connected to double cylinder internal combustion Diesel engines of the vertical type. This units are used accidentally. They consume 0.789 lbs, of gas oil per KWH, the Sp. Gr. of the gas oil being 0.857 which costs three times as much as fuel oil or tar; making the cost per KWH about the same as that of the turbines with the disadvantage that the Diesel engines require a higher cost in operation and repairs.

#### COST AND PROFIT.

The cost of tratment in the refinery based on 12,000

barrels a day is as follows: (Figures in Mexican Curreney  
one dollar = 2 pesos a day) 10% interest and depreciation  
..... 2117.00

Refining Cost

15 Stills for crude oil	443.00
8 Re-distillation Stills	237.00
7 Lubricant Stills.	119.00
Acid for the Agitators	924.
Electric Power	26.
Steam Boler	742.
Management	1779.
	<u>6378</u>
10% on total.....	638
TOTAL.....	<u>7016.00</u>

This daily cost devided by 12,000 barrels gives a  
cost of 0.593 cents per barrel or \$4.08 per ton.

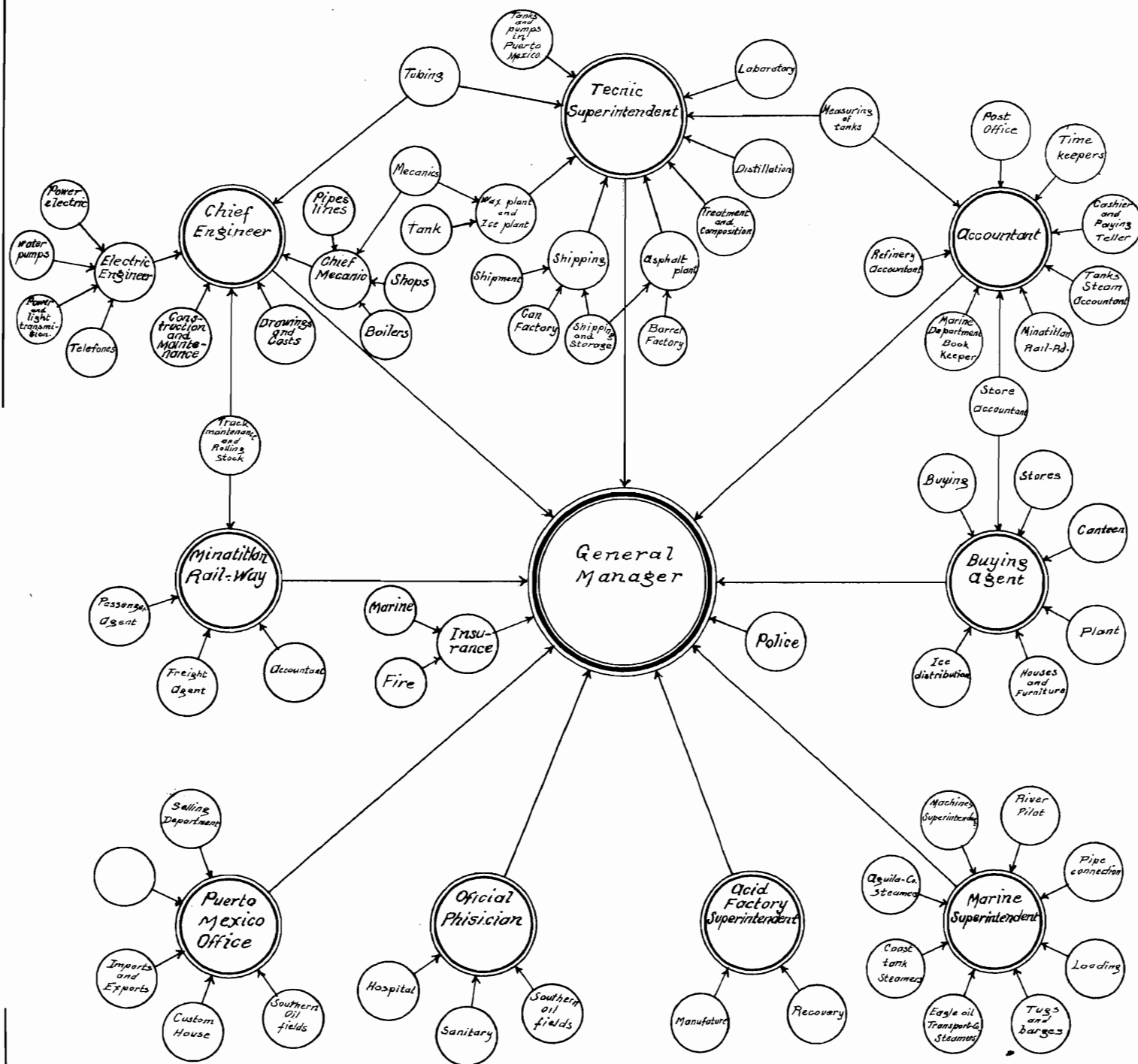
Profit per 100 tons is as follows cost of 100 tons  
crude oil at \$8.00 per ton.....\$800  
Cost of treatment per 100 tons..... 408

The crude oil as a rule is treated so  
as to produce 70% fuel oil and 30%  
distillates.

Selling prise of 70 tons fuel-oil at \$4.00.....	280.
" " " 30 " distillates at 60.00.....	1800
	<u>1208.00-2080.00</u>
Profit	<u>872.00</u>

Notwithstanding that hese figures are approximate and  
that they have been so as to produce a relatively low profit,  
they show that the refining industry in Mexico is very pro-  
ductive.

The administration work of the refinery is distributed



ADMINISTRATIVE ORGANIZATION

as shown in plate No. 9.

*G. Garcia Jazano.*  
B. S. L. E.

México, D.F. 21st of May- 1917.

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